Jason S. Angell, Bar No. 221607
jangell@hopkinscarley.com
Christopher A. Hohn, Bar No. 271759
chohn@hopkinscarley.com
HOPKINS & CARLEY
A Law Corporation
The Letitia Building
70 South First Street
San Jose, CA 95113-2406

mailing address:
P.O. Box 1469
San Jose, CA 95109-1469
Telephone: (408) 286-9800
Facsimile: (408) 998-4790

Attorneys for Plaintiff
GEORGE BETAK, an individual

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

GEORGE BETAK, an individual, Plaintiff, v. VALERY MIFTAKHOV, an individual; ELECTRIC MOTOR WERKS, INC., a Delaware corporation; and ENEL X NORTH AMERICA, INC., a Delaware corporation, Defendants.	CASE NO. **COMPLAINT FOR:** **(1) CORRECTION OF INVENTORSHIP (35 U.S.C. § 256)** **(2) FRAUD BY FALSE PROMISE** **(3) QUASI-CONTRACT** **(4) QUANTUM MERUIT** **(5) UNFAIR COMPETITION (BUS. & PROF. CODE 17200 *ET SEQ.*)** **(6) CONSTRUCTIVE TRUST** **(7) ACCOUNTING** **DEMAND FOR JURY TRIAL**

Plaintiff George Betak ("Plaintiff Betak" or "Betak"), by and through his attorneys, brings this Complaint for correction of inventorship on certain issued patents, common law fraud, and other claims below that arise out of a fraudulent scheme devised and carried out by Defendant Valery Miftakhov ("Defendant Miftakhov" or "Miftakhov") and Electric Motor Werks, Inc. ("Defendant EMW" or "EMW") to secure, by false promises and inducements, intellectual and other contributions from Plaintiff to a new electric vehicle charging product. Thanks to the efforts, inventions, and business contacts Plaintiff Betak contributed, Defendant Miftakhov was able to sell to Defendant Defendant Enel X North America, Inc. ("Defendant Enel X" or "Enel X") the business and technology that Betak helped create for approximately $150,000,000. Notwithstanding Plaintiff Betak's acknowledged contributions, Defendants Miftakhov and EMW later revealed that the promises an inducements made to Plaintiff Betak to secure his contributions were false when made, and they have failed to provide Betak with any compensation whatsoever. As detailed below, Plaintiff Betak has been damaged by the fraudulent and wrongful conduct of Defendants Miftakhov, EMW, and Enel X. Plaintiff Betak alleges as follows:

PARTIES

1. Plaintiff George Betak is a natural person who resides in Milpitas, California.

2. Defendant Valery Miftakhov is a natural person who, on information and belief, resides in San Carlos, California. On information and belief, Defendant Miftakhov is, and at all relevant times has been, the Chief Executive Officer of Defendant EMW and a substantial shareholder of that entity.

3. On information and belief, Defendant Electric Motor Werks, Inc. is a corporation organized and existing under the laws of the State of Delaware, with its principal place of business at 846 Bransten Rd., San Carlos, California 94070. EMW is registered to do business in California and can be served through its agent for service of process, Valery Miftakhov, at 846 Bransten Rd., San Carlos, California 94070.

4. On information and belief, Enel X is a corporation organized and existing under the laws of the State of Delaware, with its principal place of business at One Marina Park Drive,

Suite 400, Boston, MA 02210. Enel X is registered to do business in California and can be served through its agent for service of process, Cogency Global Inc., 1325 J St., Ste. 1550, Sacramento, California 95814. On information and belief, Enel X maintains a regular and established place of business in this district at 100 Montgomery Street, Suite 1400, San Francisco, CA 94104.

5. On information and belief, Enel X was previously known as EnerNOC, Inc. and changed its name to Enel X North America, Inc. on or about October 24, 2018.

JURISDICTION

6. This action arises under the patent laws of the United States, 35 U.S.C. §§ 1 *et seq.* Specifically, it seeks to correct the inventorship of issued United States patents under 35 U.S.C. § 256. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a).

7. Plaintiff Betak also brings California statutory and common law claims against the defendants. The Court has, and should assume, supplemental jurisdiction over these claims pursuant to 28 U.S.C. § 1367(a) for at least the following reasons.

8. Plaintiff Betak brings California state law claims for fraud by false promise, quasi-contract, quantum meruit, unfair competition (Cal. Bus. & Prof. Code §§ 17200 *et seq.*), constructive trust, and accounting. All of these claims arise from the same case or controversy as his patent-law claims; namely, his work with Defendants Miftakhov and EMW to found a business and develop new electric vehicle charging technology, and the failure by Miftakhov and EMW to compensate him for his efforts as agreed, or to name him as an inventor on patents addressed to technology that Plaintiff Betak invented or co-invented.

9. Accordingly, the state-law claims asserted in this action are related to claims arising under the patent laws of the United States, over which this Court has subject matter jurisdiction pursuant to 28 U.S.C. § 1331 and 1331(a), and form part of the same case or controversy under Article III of the United States Constitution. Judicial economy, convenience, and fairness to the parties to this action will result if the Court assumes and exercises supplemental jurisdiction over Plaintiff Betak's state-law claims (Counts III through VIII) pursuant to 28 U.S.C. § 1367(a).

//

VENUE

10. Venue is proper in this district under 28 U.S.C. §§ 1391(b)(1), as all the defendants are residents of California and of this district for venue purposes.

11. Venue is also proper in this district under 28 U.S.C. §§ 1391(b)(2) because a substantial part of the events giving rise to Plaintiff Betak's claims occurred in this district.

FACTUAL BACKGROUND

Plaintiff Betak And His Professional Background

12. Plaintiff Betak is an accomplished electrical engineer, software engineer, and computer scientist who has worked for some of the most significant technology and automotive companies in the United States and Europe, including Siemens, BMW, SAP Labs, Adobe Systems, Inc., Motorola Mobility, Yahoo! Inc., and Workday, Inc. Plaintiff Betak holds a Master of Science degree in Computer Science from the Augsburg University of Applied Sciences in Augsburg, Germany. During his studies at Augsburg University of Applied Sciences, he was selected by Siemens into what is known today as its "Future Minds" program, an incubator established to support the brightest and most promising future engineers.

13. Throughout his professional life, Plaintiff Betak has been intensely interested in the potential societal benefits of electric vehicles. Plaintiff Betak has, in various capacities, used his training and expertise as a technologist to advocate for the advancement of electric vehicle use. He has also developed a track record of innovation and leadership in the electric vehicle field.

14. For example, Plaintiff Betak is the co-founder and former President of a non-profit organization called the San Francisco Bay Area Nissan LEAF Owners Association (also known as the "SF BayLEAFs"). The SF BayLEAFs started as a small, *ad hoc* group of owners of Nissan LEAF electric vehicles who organized to, among other things, advocate and help develop public policy for electric vehicles and other clean energy transportation programs. Eventually, on information and belief, the SF BayLEAFs became the largest Nissan LEAF owners group in the world. Through his work with the SF BayLEAFs group, Plaintiff Betak became well-known in the local and national electric vehicle community.

15. Plaintiff Betak's thought leadership has been recognized by electric vehicle manufacturers. Through his involvement in SF BayLEAFs, Plaintiff Betak helped gather product feedback from LEAF owners for purposes of developing recommendations to Nissan on ways to improve LEAF vehicles. These efforts culminated in a meeting with Nissan's Chief Vehicle Engineer and other key Nissan engineering and product staff, where Plaintiff Betak and others shared their recommendations for the LEAF electric vehicle. Nissan later implemented many of the ideas provided in connection with that meeting.

16. Plaintiff Betak also participated in the BMW Sustainability Hackathon hosted by the BMW Technology Group in Mountain View, California on April 27 and 28, 2013. The "hackathon" was organized to gather electric vehicle technology solutions enthusiasts to, in a short period of time, brainstorm and develop proposals to address various challenging issues confronting electric vehicle operators. The ideas that Plaintiff Betak proposed won the 1st and 2nd prizes at the hackathon.

17. BMW selected Plaintiff Betak as part of a small group of individuals to participate in a field trial of BMW's ActiveE validation prototype. He also became one of the first owners and evaluators of BMW's i3 all-electric vehicle. Plaintiff Betak provided BMW with critical feedback on the ActiveE and the i3, much of which was adopted by BMW.

18. Additionally, since November 2014, Plaintiff Betak has helped create and build what, on information and belief, has become the largest online community of current and prospective owners of Tesla's Model 3 electric vehicle, with approximately 45,000 members. On information and belief, Tesla regularly recommends that new and prospective owners of the Model 3 join this community to access technical and sales information, to learn about Tesla's products, and to be educated about the Model 3's advanced features.

19. Throughout his work in the electric vehicle community, Plaintiff Betak has built a positive reputation and network of contacts among vehicle manufacturers, and the people and companies that develop products for use in electric vehicles. Plaintiff Betak has earned the trust of drivers, vendors, car manufacturers, and industry peers.

//

Early Meetings Between Plaintiff Betak And Defendant Miftakhov, And Their Discussions Regarding JuiceBox

20. On information and belief, Defendant Miftakhov began work in the electric vehicle space by creating a "kit" that could be used to convert standard internal combustion vehicles into electric vehicles. On information and belief, Defendant Miftakhov incorporated EMW in Delaware in December 2011, and sold the electric vehicle conversion kits through EMW beginning in 2012, and continuing through at least 2013.

21. Plaintiff Betak first met Defendant Miftakhov in July of 2013 at an SF BayLEAFs meeting ("July 2013 SF BayLEAFs Meeting") hosted by Nissan USA at their Research Center in Sunnyvale, CA.

22. At the July 2013 SF BayLEAFs Meeting, Defendant Miftakhov was promoting an EMW Kickstarter fundraising campaign, which sought to raise money to fund the development and production of an open source do-it-yourself kit for building a level 2 electric vehicle charging station. A level 2 charging station uses a 240-volt outlet (such as the outlet used by many household electric dryers), as opposed to level 1 charging stations, which use a conventional 120-volt outlet common in most homes. As a result, a level 2 charging station can charge an electric vehicle more quickly than a level 1 charging station. While many other level 2 charging stations were available on the market at that time, Defendant EMW's Kickstarter campaign promised that its charging station, known as "JuiceBox," would be less expensive. Due to its open-source nature, JuiceBox would also be more accommodating than other charging stations to those wishing to implement enhancements and modifications to its standard feature set.

23. At the meeting, Defendant Miftakhov and Plaintiff Betak discussed their shared interest in electric vehicles and their involvement in the electric vehicle industry. The two remained in contact after the event.

24. On May 15, 2014, Plaintiff Betak met with Defendant Miftakhov again and proposed the idea of making a new JuiceBox product in which every JuiceBox unit would be Wi-Fi-enabled and "connected" to the internet, and in which the units could collectively operate in communication with other entities and information sources, such as grid operators and energy

providers. This, as Plaintiff Betak explained, could add substantial economic benefits that far exceeded the cost of adding Wi-Fi functionality to every JuiceBox unit. A connected charging station would also provide a superior experience to electric car drivers, which would help hasten its adoption and increase the value of the resulting charging station network.

25. Plaintiff Betak subsequently worked with Defendant Miftakhov and others to refine the system that Betak had envisioned, including through periodic communications, meetings, and "brainstorming" sessions. Through these joint efforts, they determined that the system that Betak contemplated could use cloud-based software and data from grid operators and energy providers to automatically charge the electric vehicles during periods when the energy providers and grid operators offered electricity at lower prices. For example, by automatically charging vehicles during non-peak hours (to the extent possible), the system can allow electric vehicle owners to obtain better electricity pricing than they would receive if they inadvertently charged their vehicles during periods of high energy usage, and an easier user experience than if they attempted to manually schedule their charging in this manner.

26. Similarly, the system that Plaintiff Betak conceived and which he helped refine could maximize vehicle charging during times when electricity from renewable sources, such as solar and wind power systems, is more readily available, thereby accelerating the adoption of renewable energy and reducing the amount of electricity that must be generated using fossil fuels.

27. Moreover, by controlling the collective network of JuiceBox charging stations, the system that Plaintiff Betak conceived and helped refine could generate a new revenue stream. Grid operators and energy providers offer incentives to large electricity users, essentially paying them to reduce their electricity usage during peak usage periods. During those periods, the system could reduce the electricity usage of a large number of charging stations within the network, thereby taking advantage of these economic incentives.

<u>Plaintiff Betak And Defendant Miftakhov Begin Collaborating On JuiceBox/JuiceNet Project</u>

28. On May 21, 2014, Defendant Miftakhov approached Plaintiff Betak about collaborating on the next generation of the JuiceBox product, which would include the

connectivity features that Betak had proposed. The JuiceBox product that eventually resulted from this collaboration was controlled using a platform called "JuiceNet," which included, among other things, software and a mobile device application that uses historical patterns, real-time input, and data from energy providers, grid operators, and other sources to aggregate and manage charging station usage.

29. On information and belief, Defendant Miftakhov desired collaboration with Plaintiff Betak on the JuiceBox/JuiceNet project to gain access to Plaintiff Betak's knowledge about the electric vehicle industry and technology, to gain access to Betak's vast network within the electric vehicle community, and to secure Betak's intellectual contributions to JuiceBox and JuiceNet.

30. On or about June 6, 2014, in a Facebook Messenger exchange between Defendant Miftakhov and Plaintiff Betak regarding the JuiceBox/JuiceNet collaboration, Miftakhov stated to Betak: "George I won't do it without you." Defendant Miftakhov offered, and Plaintiff Betak agreed, that Plaintiff Betak would join the effort in a "co-founder sort of role" of the business that resulted from the JuiceBox/JuiceNet collaboration.

31. Defendant Miftakhov proposed to Plaintiff Betak that their collaboration would be under the auspices of a new company called EV Juice, Inc. ("EV Juice"), rather than through EMW. Defendant Miftakhov explained that EMW was burdened by what Miftakhov described as "baggage" related to its other founders and shareholders. To convince Plaintiff Betak to join the collaboration, Defendant Miftakhov represented to Betak that if Betak agreed to collaborate on the JuiceBox/JuiceNet project, Betak would—as a co-founder and primary contributor to the technical and marketing efforts for JuiceBox/JuiceNet—share in the proceeds resulting from the work as a partial owner, including in any sale of the company.

32. In September of 2014, Defendant Miftakhov presented Plaintiff Betak with an "Employment Offer Letter" and "Intellectual Property And Confidentiality Agreement" drawn up for EV Juice ("EV Juice Offer Letter" and "EV Juice IP Agreement," respectively).

33. The EV Juice Offer Letter stated that Plaintiff Betak's compensation would be "$0 annualized" and that he would be entitled to "such vacation, medical and other employee benefits

as the Company may offer from time to time, subject to applicable eligibility requirements." In lieu of pay, the letter also described an initial equity grant that "corresponds to 3% (three percent) of the Company's issued shares at the time of this offer."

34. Plaintiff Betak signed the EV Juice documents. Betak did not sign any agreements with EMW.

Plaintiff Betak's Work On JuiceBox/JuiceNet

35. In reliance on Defendant Miftakhov's promises and representations that Plaintiff Betak would share as a co-founder in the proceeds resulting from the collaboration, Betak worked without pay for well over a year on the JuiceBox/JuiceNet project.

36. At the time he began working on this project, no commercially viable JuiceBox or JuiceNet product existed. At the time Plaintiff Betak and Defendant Miftakhov began working together on the JuiceBox/JuiceNet project, Betak was the only formally-trained engineer working on the project.

37. While Defendant Miftakhov had represented to Plaintiff Betak that work on the JuiceBox/JuiceNet project would be performed under the auspices of EV Juice, and that he and Betak would share in the proceeds of the product developed by EV Juice, Miftakhov steered the project in a direction different from that proposed to Betak. Defendant Miftakhov and EMW held out the JuiceBox/JuiceNet project and product development as an EMW endeavor, not an EV Juice endeavor, and held out Plaintiff Betak as part of the EMW organization. Because the project progressed under EMW, Betak never worked for EV Juice, as an employee or otherwise.

38. Indeed, shortly after Betak signed the EV Juice documents, he was assigned an EMW email account for his work on the JuiceBox/JuiceNet project.

39. Further, on information and belief, shortly after Plaintiff Betak signed the EV Juice documents, Defendant Miftakhov began hiring additional personnel to work for EMW on the JuiceBox/JuiceNet project. On information and belief, neither Defendant Miftakhov nor anyone else hired any personnel to work for EV Juice on the project.

40. During Plaintiff Betak's involvement with the JuiceBox/JuiceNet project, Defendant Miftakhov and EMW publicly identified Betak as EMW's "VP, Business Development & Community," including on EMW's website.

41. Neither Defendant Miftakhov, nor Defendant EMW, nor EV Juice provided Plaintiff Betak with code-compliant paystubs, paid any wages, or provided any of the other required benefits of employment, including the vacation, medical, and other benefits promised in the purported EV Juice Offer Letter. Indeed, after Betak signed the EV Juice Offer Letter and IP Agreement, Miftakhov never again mentioned EV Juice during the period that Betak was working on the JuiceBox/JuiceNet project.

42. Over the course of Plaintiff Betak's work on the JuiceBox/JuiceNet project, Defendant Miftakhov repeatedly reaffirmed his promise that Betak would share in the proceeds resulting from the work as a partial owner, including in any sale of the business.

43. For example, in an email exchange between Defendant Miftakhov and Plaintiff Betak on November 9, 2015, Betak stated that he planned to "continue actively participating in [Defendant EMW's] business activities…until the next investment round closes," at which point the business, and his promised partial ownership, would be more valuable, and Plaintiff Betak at that point would be compensated for his contributions to EMW. Defendant Miftakhov confirmed "that was my understanding, as well."

<u>Plaintiff Betak's Contributions To JuiceBox/JuiceNet And The Related Patent Filings</u>

44. Although Defendant Miftakhov and Plaintiff Betak agreed that Betak would work part-time, Betak actually worked full-time on the JuiceBox/JuiceNet project for the first nine months of their collaboration. Over the course of his work on the JuiceBox/JuiceNet project with Miftakhov and others, Betak conceived, or helped conceive, many significant inventions that were ultimately incorporated into the project.

45. For instance, as explained above, Plaintiff Betak conceived and worked with others to refine the concept of making every JuiceBox "connected" via Wi-Fi and the JuiceNet cloud-based software, including with the grid operators and energy providers, so that the resulting system can automatically charge the electric vehicles during times when electricity is inexpensive

and reduce charging when the grid operators and energy providers offer incentives for reducing electricity usage.

46. Plaintiff Betak also conceived of the idea of adding and communicatively coupling a revenue-grade electric meter with each JuiceBox charging station. On information and belief, no other mass-produced residential EV charging stations on the market at that time included such a meter, which allows the JuiceBox system to accurately measure the energy usage of each charging station. As a result, on information and belief, the other charging stations on the market could not be readily used in sub-metering and demand response pilot programs with electrical utilities. Instead, they would usually require expensive and time-consuming certification, or costly additional instrumentation.

47. Moreover, Betak conceived of and promoted the idea of using a "user preference" approach for the software controlling each JuiceBox charging station, in which the user would enter their charging preferences (e.g., minimizing charging cost versus minimizing charging time, the time of day that the user typically connects their vehicle to the JuiceBox system), and the software would then model and control the charging station based on the user's preferences and their actual charging behavior. In this way, the system could minimize the need for active user input.

48. Further, many if not all of the other significant inventions associated with the JuiceBox/JuiceNet project were the result of meetings in which Defendant Miftakhov, Plaintiff Betak, and sometimes others all actively participated and collaborated in the conception of the inventive ideas.

49. Defendants Miftakhov and EMW, through counsel, filed various patent applications with the United States Patent and Trademark Office ("USPTO") describing inventions that Plaintiff Betak invented or helped to invent, including by conceiving of the inventive elements described above (collectively the "Applications at Issue"). This includes U.S. Patent Application Nos. 14/853,955, 15/004,976, 15/004,974, 15/225,821, 15/004,980, 15/690,275, and 15/444,325, and U.S. Provisional Application Nos. 62/050,147 and 62/300,073.

50. On information and belief, Defendants Miftakhov and EMW were aware of Plaintiff Betak's significant contributions to the conception of the inventions described and claimed in the Applications at Issue. Nevertheless, Miftakhov and EMW failed to identify Betak as an inventor in filing and prosecuting some of these applications (all of which named Miftakhov as an inventor or joint inventor). Defendants Miftakhov and EMW also excluded Plaintiff Betak from the process of filing and prosecuting the Applications at Issue.

51. For example, Plaintiff Betak and Defendant Miftakhov are named as co-inventors in U.S. Patent Application No. US 15/444,325, entitled "Standalone Adapter for Load Control of Energy Storage Devices," which claims priority from U.S. Provisional Application No. 62/300,073 (the "'073 Provisional Application"). In broad terms, the '073 Provisional Application covers an adapter for a standard electric vehicle charging station that gives the system many of the features associated with the JuiceBox/JuiceNet product, such as the ability to "connect" with backend software and with the electrical utilities, and to automatically charge the electric vehicle when electricity is inexpensive and reduce charging when the utilities offer incentives for doing so. Betak helped conceive of this invention (the "Adapter Invention") during his work on the JuiceBox/JuiceNet project.

52. In February of 2016, Plaintiff Betak observed Defendant Miftakhov speaking with Defendant EMW's attorney at EMW's offices. He eventually learned that Miftakhov and the attorney were preparing a patent application for the Adapter Invention without Betak's knowledge, involvement, or consent, and were not planning to name Betak as an inventor. Betak objected to his omission as an inventor. As a result of his objections, Plaintiff Betak was then added as a co-inventor in the '073 Provisional Application.

53. On information and belief, Defendants Miftakhov and EMW would not have named Plaintiff Betak as a co-inventor in the '073 Provisional Application if Betak had not discovered Miftakhov and the attorney preparing this application and objected to his not being named as an inventor.

54. On or about June 5, 2018, the USPTO granted and issued United States Patent No. 9,987,941, entitled "Systems and Methods for Local Autonomous Response to Grid Conditions

by Electric Vehicle Charging Stations," a copy of which is attached hereto as Exhibit A and incorporated herein by reference (the "'941 Patent"). The '941 Patent issued from Application No. 14/853,955, filed on September 14, 2015. Plaintiff Betak contributed to the technologies claimed in the '941 Patent. However, the '941 Patent does not identify Betak as an inventor.

55. On July 17, 2018, the USPTO granted and issued United States Patent No. 10,025,277, entitled "Systems and Methods for Electrical Charging Load Modeling Services to Optimize Power Grid Objectives," a copy of which is attached hereto as Exhibit B and incorporated herein by reference (the "'277 Patent"). The '277 Patent issued from Application No. 15/004,976, filed on January 24, 2016. Plaintiff Betak contributed to the technologies claimed in the '277 Patent. However, the '277 Patent does not identify Betak as an inventor.

56. On information and belief, Defendant Miftakhov and other purported inventors assigned their rights to the inventions claimed in the '941 and '277 Patents to Defendant EMW. This alleged assignment occurred without Betak's knowledge or consent.

57. Plaintiff Betak did not execute, and has not executed, any assignments with regard to the Applications at Issue, or any patents that resulted from these applications.

58. Plaintiff Betak's technical contributions to JuiceBox/JuiceNet extended beyond those for which Defendants Miftakhov and EMW sought patent protection. For example, Betak identified and sourced key components for the JuiceBox device.

59. Among other components, Plaintiff Betak identified and helped implement the JuiceBox's Wi-Fi module, which is the heart of JuiceBox's connected features.

60. Plaintiff Betak was also instrumental in improving the JuiceBox's electricity metering functionality.

61. Further, aside from JuiceBox, Plaintiff Betak's contributions resulted in three other JuiceNet smart-metering products: the WattBox, the JuicePlug, and the JuiceMeter.

62. In addition to his technical contributions, Plaintiff Betak made many other substantial contributions to the JuiceBox/JuiceNet project. Among other things, he was responsible for the business development, marketing, and customer and electric vehicle user outreach efforts to promote JuiceBox/JuiceNet.

63. For example, Plaintiff Betak developed solutions that have successfully overcome regulatory barriers and filled technological gaps, which enabled the JuiceBox/JuiceNet project to be accepted by Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric for the California Public Utilities Commission's Plug-In Electric Vehicle Submetering Pilot program. This was the first successful project with a utility for the JuiceBox/JuiceNet product, and it elevated the profile of the company and set the stage for other utility projects and strategic partnerships.

64. As another example, Plaintiff Betak was instrumental in establishing strategic partnerships involving JuiceBox/JuiceNet, including partnerships with several notable companies including PlugShare (Recargo), OhmConnect, Honda, and OSIsoft. He also garnered sustained favorable publicity for EMW from InsideEVs, a source for electric-vehicle-related news, product review, forums, and other media, through his personal connection with the co-founder of InsideEVs and his previous contributions to InsideEVs.

65. Further, Plaintiff Betak championed and initiated the process of offering the JuiceBox/JuiceNet product for sale through Amazon Prime. He also worked on partnerships with popular electric vehicle websites and industry influencers, which helped contribute to substantial and sustained direct sales of the JuiceBox/JuiceNet product and to its quick adoption in the electric vehicle community.

66. Plaintiff Betak was also responsible for using his connections and reputation within the electric vehicle community to identify and attract key employees to work on the JuiceBox/JuiceNet Project. He also helped train the new employees once they began work.

67. By May of 2015, Plaintiff Betak determined that, without regular pay or investment rounds on the foreseeable horizon, continuing to work full-time on only the JuiceBox/JuiceNet project was not sustainable, and that he would need additional employment with a regular paycheck. Others working on the project had similar arrangements for similar reasons. Notably, until approximately the end of 2016, Defendant Miftakhov was employed full-time at Google, and worked on the JuiceBox/JuiceNet project in his spare time. In or around June of 2015, Betak accepted a position at UC Berkeley. Nevertheless, Plaintiff Betak continued to

work on the JuiceBox/JuiceNet project on a part-time basis, as Defendant Miftakhov requested, and based upon Miftakhov's further assurances that Betak would be compensated when funding was secured or the company was sold. On January 12, 2016, for example, Defendant Miftakhov sought additional financial investment from the EMW "management team," including Plaintiff Betak, through a convertible note offering that would return a premium to investors upon either a Series A round of investment, or acquisition of the company within a specified time frame. While Plaintiff Betak did not participate in the convertible note offering, the clear message was that investors that had acquired equity, including Plaintiff Betak, would be compensated in accordance with acquired equity upon an investment round or an acquisition event.

68. Plaintiff Betak remained on the EMW management email distribution list, mteam@emotorwerks.com, and continued receiving emails sent to the EMW management team until approximately July of 2016. In addition to including Betak on management-level correspondence, Defendant EMW continued to exploit Betak's prominence in the electric vehicle community. For example, EMW publicly identified Plaintiff Betak as a member of its management team until approximately November of 2016.

<u>Enel X Acquires EMW And Defendants Falsely Claim That Plaintiff Betak Has Assigned His IP Rights To EMW</u>

69. On September 12, 2017, Defendant Miftakhov called Plaintiff Betak and informed him that Defendant EMW was going to be acquired by a European energy company. On information and belief, Enel X (which was then known as EnerNOC, Inc.) acquired EMW on October 25, 2017. On information and belief, the acquisition price was €130 million (approximately $153,460,000 at the exchange rate at the time), of which €31 million was paid in cash at the time of the acquisition. Also on information and belief, the remainder of the acquisition price was paid in or about April 2019.

70. On information and belief, Enel X acquired all of Defendant EMW's assets, including all of EMW's patents, patent applications, and other intellectual property, through this acquisition. Plaintiff Betak was not asked to consent to, and did not consent to, the purported transfer of the '941 Patent, the '277 Patent, or any other intellectual property rights to Enel X.

71. Prior to Enel X's announced acquisition of Defendant EMW, Plaintiff Betak had no reason to know or suspect that Defendants Miftakhov and EMW would not provide him with the compensation that had been promised in order to induce him to work on the JuiceBox/JuiceNet project. On information and belief, EMW was operating at a loss as of the 2017 acquisition. Therefore, until the acquisition by Enel X, and the initial acquisition payments made by Enel X, there was no reason to believe that the Defendants Miftakhov and EMW would not pay Plaintiff Betak for his work on, and contributions to, the JuiceBox/JuiceNet project, or that the representations Miftakhov made to induce Betak to help develop JuiceBox/JuiceNet were false.

72. After Defendant Miftakhov told Plaintiff Betak about the impending acquisition, Betak asked Miftakhov about the financial details of the acquisition and how the number of shares representing his equity would be determined. Defendant Miftakhov refused to provide the requested information. Rather than providing the requested information, Miftakhov attempted to mislead Betak in a manner that, on information and belief, was intended to enable Miftakhov and Defendant EMW to induce Betak to accept less than what he had been promised for his contributions to JuiceBox/JuiceNet and EMW. Initially, Miftakhov stated that EMW's outside counsel would be contacting Betak about "missing paperwork."

73. On October 6, 2017, Defendant EMW's counsel advised Plaintiff Betak that he "currently has 15,000 of the fully vested shares" of EMW stock and requested that Betak sign certain documents affirming that conclusion. Later that day, in response to inquiries from Betak's counsel, Defendant Miftakhov stated that "George's original grant was 48,000 shares, vesting on a monthly basis for as long he continued providing services for the company as a contractor, never a W-2 employee." Miftakhov's attempt to characterize Betak's status "as a contractor, never a W-2 employee" was not consistent with the terms of the "Employment Offer" he transmitted to Betak in September 2014. Defendant Miftakhov's 2017 statement indicates that the statements Miftakhov made in 2014 were false at the time they were made. Nevertheless, while Defendants Miftakhov and EMW appear to acknowledge now the obligation to compensate Plaintiff Betak, they have not provided to Betak even the undisputed amounts. Instead, by

withholding the compensation acknowledged to be due, Defendants Miftakhov and EMW have sought to leverage Plaintiff Betak into taking less than what he is owed.

74. Moreover, Defendants Miftakhov and EMW repeatedly have tried to coerce Plaintiff Betak into executing documents to forfeit his rights to his inventions, despite the fact that Defendants Miftakhov and EMW have no right to make such a demand. On information and belief, Defendants Miftakhov, EMW, and Enel X are aware that Plaintiff Betak did not assign any rights in his inventions to EMW, or any other party. On information and belief, Miftakhov, EMW, and Enel X also are aware that, having provided no consideration for Betak's contributions, Miftakhov and EMW have no rights to have Betak's inventions assigned to EMW or any other party. However, as the transaction with Defendant Enel X was being finalized, Defendants Miftakhov and EMW sought to convince Plaintiff Betak to assign his rights to his inventions to EMW for no consideration whatsoever. On November 2, 2017, EMW's counsel stated—incorrectly—that Betak had executed an intellectual property assignment agreement with EMW that required him to execute formal invention assignment documents as to inventions that he created while collaborating on the JuiceBox/JuiceNet project. This came as a surprise to Plaintiff Betak, who had never executed any agreements with Defendant EMW. At no time during Betak's work on the JuiceBox/JuiceNet project did Miftakhov or EMW ask Betak to sign any agreements of any kind with EMW. Plaintiff Betak's counsel requested a copy of the purported IP assignment agreement.

75. On November 7, 2017, Defendant EMW's counsel transmitted what it described as Plaintiff Betak's "binding IP assignment agreement" with EMW. In the transmitting email, EMW's counsel stated that any payment to Betak would be "conditioned" on "confirmation" of the "binding IP assignment agreement" attached to the email. The file EMW's counsel transmitted included a document entitled "Electric Motor Werks, Inc. Intellectual Property and Confidentiality Agreement," and included a signature page purporting to bear Plaintiff Betak's signature ("EMW IP Agreement"). On information and belief, some or all of the defendants removed or caused to be removed the signature page from the EV Juice IP Agreement and attached it to the purported EMW IP Agreement in attempt to mislead Betak into believing that he

had agreed to assign his intellectual property rights to EMW. Plaintiff Betak, through counsel, pointed out that the EMW IP Agreement was obviously not genuine. In subsequent discussions and correspondence between counsel, Defendants Miftakhov and EMW have not disputed that the purported EMW IP Agreement is not genuine, or contended that Plaintiff Betak did in fact execute such a document.

76. Having failed to mislead Plaintiff Betak into executing formal assignment documents for his inventions, Defendants Miftakhov, EMW, and, on information and belief, Enel X, have sought to have Betak execute agreements assigning his inventions to EMW. In particular, EMW's outside patent counsel contacted Betak on several occasions and requested that Betak execute invention assignment documents. These efforts by EMW's patent counsel include confronting Plaintiff Betak on the evening of October 9, 2018 in a parking lot at an electric vehicle industry event and demanding that Betak execute assignment documents immediately, on the spot. Plaintiff Betak declined to forfeit his rights.

77. On information and belief, since its acquisition by Defendant Enel X, Defendant EMW has remained in operation, and Defendant Miftakhov has continued as its CEO.

78. Plaintiff Betak has not been paid anything for his contributions to Defendant EMW and the JuiceBox/JuiceNet project, either upon the sale of EMW or at any other time. Nor has Betak received any other type of benefit or consideration for his contributions from EMW, Enel X, or any other party.

COUNT I

(Correction Of Inventorship Of The '941 Patent Against All Defendants (35 U.S.C. § 256))

79. Plaintiff Betak incorporates his allegations in paragraphs 1-78, above, as if fully set forth herein.

80. The '941 Patent does not list Plaintiff Betak as an inventor or joint inventor.

81. Plaintiff Betak is one of the inventors of the inventions that are the subject of the '941 Patent. The application that resulted in the '941 Patent was filed on September 14, 2015, and claims priority to a provisional application that was filed on or about September 14, 2014. Plaintiff Betak made significant contributions to the conception and reduction to practice of those

inventions, including, for example, the technology claimed in claims 1 and 11 of the '941 Patent, the only two independent claims of the '941 Patent. Claims 1 and 11 of the '941 Patent purport to claim, for example, the "connected" electric vehicle charging system and method that Betak first proposed to Defendant Miftakhov in May 2014, approximately four months before the provisional application was filed in September 2014. Claims 1 and 11 also claim the use of an electricity meter at the charging station, another one of Betak's inventive contributions.

82. The omission of Plaintiff Betak as a co-inventor of the '941 Patent was done without Betak's participation and without any deceptive intent on the part of Plaintiff Betak.

83. Because Plaintiff Betak is a rightful co-inventor of the '941 Patent, this Court should issue an order directing the Commissioner of Patents to add Betak as a co-inventor of the '941 Patent, in addition to ordering any other remedies due to Betak.

84. In addition to the other harm that the defendants have caused Plaintiff Betak, their actions in failing (or refusing) to recognize and identify Betak as a co-inventor of the '941 Patent have damaged Betak's reputation as an innovator in the electric vehicle community by indicating—incorrectly—that he did not contribute to the conception of the inventive ideas described in the '941 Patent and embodied in the JuiceBox/JuiceNet project, despite his considerable contributions to the technology that supports the products.

COUNT II

(Correction Of Inventorship Of The '277 Patent Against All Defendants (35 U.S.C. § 256))

85. Plaintiff Betak incorporates his allegations in paragraphs 1-84, above, as if fully set forth herein.

86. The '277 Patent does not list Plaintiff Betak as an inventor or joint inventor.

87. Plaintiff Betak is one of the inventors of the inventions that are the subject of the '277 Patent. The application that resulted in the '277 Patent was filed on January 4, 2016, and claims priority to a provisional application that was filed on or about September 14, 2014. Plaintiff Betak made significant contributions to the conception and reduction to practice of those inventions, including, for example, the technology claimed in claims 1 and 12 of the '277 Patent, the only two independent claims of the '277 Patent. Claims 1 and 12 of the '277 Patent purport to

claim, for example, a "computerized system" and "computer-implemented method" for load-modeling to enable an electrical grid to deliver power efficiently to "charging assets" for use in charging electric vehicles, for use with the "connected" electric vehicle charging system and method that Plaintiff Betak first proposed to Defendant Miftakhov in May 2014, approximately four months before the provisional application was filed in September 2014. As another example, claims 1 and 12 require the determination of a "charging pattern for each of the plurality of charging assets" and controlling "charging of the plurality of charging assets in accordance with the determined charging patterns." This claims the "user preference" approach for controlling the JuiceBox charging station that Plaintiff Betak proposed, in which the software models and controls the charging station based on the user's actual charging behavior.

88. The omission of Plaintiff Betak as a co-inventor of the '277 Patent was done without Betak's participation and without any deceptive intent on the part of Betak.

89. Because Plaintiff Betak is a rightful co-inventor of the '277 Patent, this Court should issue an order directing the Commissioner of Patents to add Betak as a co-inventor of the '277 Patent, in addition to ordering any other remedies due to Betak.

90. In addition to the other harm that the defendants have caused Plaintiff Betak, their actions in failing (or refusing) to recognize and identify Betak as a co-inventor of the '277 Patent have damaged Betak's reputation as an innovator in the electric vehicle community by indicating—incorrectly—that he did not contribute to the conception of the inventive ideas described in the '277 Patent and embodied in the JuiceBox/JuiceNet project, despite his considerable contributions to the technology that supports the products.

COUNT III

(Fraud By False Promise Against Miftakhov And EMW)

91. Plaintiff Betak incorporates his allegations in paragraphs 1-90, above, as if fully set forth herein.

92. Defendants Miftakhov and EMW engaged in a fraudulent scheme to induce Plaintiff Betak to contribute to the JuiceBox/JuiceNet project without pay and to take for

themselves the fruits of Betak's efforts and contributions, including the intellectual property and proceeds from the acquisition of EMW and intellectual property Plaintiff Betak helped invent.

93. Defendant Miftakhov, acting in his individual capacity and as the CEO of Defendant EMW, promised Plaintiff Betak that their collaboration would be under the auspices of a new company called EV Juice, Inc. Miftakhov and, by extension, EMW also promised and repeatedly reassured Betak that Betak would share in the proceeds resulting from their collaboration as a partial owner, including in any profits from the sale of the business that Betak and Miftakhov both worked to found and build.

94. On information and belief, Defendant Miftakhov did not intend to perform these promises when he made them, as he and Defendant EMW: (1) held out the JuiceBox/JuiceNet project as an EMW product, rather than an EV Juice product; (2) quickly began hiring personnel through EMW to work on the JuiceBox/JuiceNet project; (3) held out Plaintiff Betak as a member of the EMW team; (4) falsely claimed in 2017 that Betak was "a contractor, never a W-2 employee" for EMW all along; and (5) provided Betak with the false EMW IP Agreement in attempt to mislead Betak into believing he had assigned away his intellectual property rights.

95. On information and belief, Defendants Miftakhov and EMW made these promises in attempt to induce Plaintiff Betak to work on the JuiceBox/JuiceNet project without pay, so that Defendants Miftakhov and EMW could reap the benefits of Betak's engineering and business development efforts, his extensive knowledge about the electric vehicle industry and technology, his substantial network within the electric vehicle community, and his intellectual contributions to JuiceBox and JuiceNet. Later, Defendants Miftakhov and EMW sought to mislead Plaintiff Betak into forfeiting his rights and accepting a proportion of "equity ownership" in EMW that was substantially less than Defendant Miftakhov had originally promised to Plaintiff Betak.

96. Plaintiff Betak justifiably and reasonably relied on Defendant Miftakhov's promises and assurances, including by working on the JuiceBox/JuiceNet project without pay, with the expectation that he would share in the eventual sale of the business, as had been represented to him.

97. Defendants Miftakhov and EMW did not perform on the promises Miftakhov made on his and EMW's behalf, including by failing to share any of the proceeds from the collaboration on the JuiceBox/JuiceNet project with Plaintiff Betak, despite the sale to Enel X. Until that sale was announced in 2017 and the initial payments made by Enel X, Betak had no reason to believe that Miftakhov and EMW would not compensate him for his work and contributions, as Plaintiff Betak had been promised. On information and belief, until the point at which Enel X acquired EMW, EMW had been operating at a loss and no return on equity ownership had been provided to any equity holders. Plaintiff Betak did not discover, due to Defendant Miftakhov's and EMW's concealment of their intent to not compensate Plaintiff Betak upon the sale of EMW to Enel X and payment by Enel X to EMW of at least part of the acquisition payment in or about October 2017, that Defendants Miftakhov and EMW had mislead him and fraudulently induced him into contributing his intellectual and business efforts to creating the JuiceBox/JuiceNet products.

98. On information and belief, Defendant Enel X knew of the fraudulent scheme after learning of it during the pre-acquisition due diligence process associated with the acquisition of EMW. On information and belief, Enel X gave substantial assistance and encouragement to Defendants Miftakhov and EMW in their perpetuation of the fraudulent scheme, including by: (i) proceeding with the acquisition despite having knowledge of the fraudulent scheme; (ii) endorsing and ratifying Miftakhov and EMW's refusal to compensate Plaintiff Betak before and after the acquisition, a course of action over which Enel X had substantial control as a result of the acquisition; and (iii) working with Miftakhov and EMW to avoid compensating Betak for his work on the JuiceBox/JuiceNet project. On information and belief, Enel X engaged in this conduct because compensating Betak for his contributions and confirming his intellectual property rights would have reduced the value of the EMW business that Enel X acquired. On information and belief, Enel X's actions provided substantial assistance and encouragement to Miftakhov and EMW in the perpetuation of the fraudulent scheme, and was a substantial factor in causing the perpetuation of the fraudulent scheme.

99. As a direct and proximate result of the foregoing, Plaintiff Betak was harmed, including by not receiving any payment for his contributions to the JuiceBox/JuiceNet project, by not being named on patents covering inventions that he helped invent, and by losing out on the opportunity to work for pay elsewhere during the time that he was working on JuiceBox/JuiceNet.

100. By virtue of the above-described conduct, Defendant Miftakhov and EMW acted with fraud, oppression, and malice and Plaintiff Betak is entitled to an award of exemplary or punitive damages.

COUNT IV

(Quasi-Contract And Restitution Against Miftakhov And EMW)

101. Plaintiff Betak incorporates his allegations in paragraphs 1-100 above, as if fully set forth herein.

102. Plaintiff Betak and Defendants Miftakhov and EMW, by their conduct and based on their relationship, entered into a contract that may be implied in law. Defendant Miftakhov offered that if Plaintiff Betak contributed his intellectual energy, technical expertise, and business contacts to the effort to build the JuiceBox/JuiceNet product, Betak would share in the proceeds from the commercialized product, including in any sale of the business. Plaintiff Betak accepted and did contribute his efforts and energies, and Betak's contributions helped produce a viable commercial product. On the basis of the strength and success of the JuiceBox/JuiceNet product and the associated intellectual property that Betak was instrumental in creating, Defendants Miftakhov and EMW sold EMW to Enel X. On information and belief, Defendants Miftakhov and EMW have retained the amounts received in the sale. Miftakhov and EMW have not provided Plaintiff Betak with any of the proceeds from the sale of EMW to Enel X including, at a minimum, a share of the sale proceeds that are attributable to Plaintiff Betak's significant contributions to EMW and the JuiceBox/JuiceNet products.

103. Restitution is necessary to avoid unjust enrichment of Defendants Miftakhov and EMW at the expense of Plaintiff Betak.

COUNT V

(Quantum Meruit Against Miftakhov And EMW)

104. Plaintiff Betak incorporates his allegations in paragraphs 1-103, above, as if fully set forth herein.

105. Defendant Miftakhov, who on information and belief is and at all relevant times was the CEO of EMW, requested that Plaintiff Betak work on the JuiceBox/JuiceNet project. For example, as Miftakhov expressed it in a message to Betak, "George I won't do it without you."

106. Plaintiff Betak worked on the JuiceBox/JuiceNet project, making substantial contributions to the design and development, marketing, promotion, and underlying intellectual property of the JuiceBox/JuiceNet product. Betak's technological and other contributions resulted in a commercially viable product that attracted the attention of investors and, on information and belief, led to the acquisition of Defendant EMW by Defendant Enel X. Betak's services, which helped grow EMW from a small startup with no commercially-viable product into an established business that Enel X purchased for €130 million, provided substantial value and benefit to the defendants.

107. Plaintiff Betak has not received any compensation for the contributions he made at the request of Defendants Miftakhov and EMW, including in particular any share of the acquisition of EMW attributable to his contributions to the JuiceBox/JuiceNet product and its success.

COUNT VI

(Unfair Competition Against All Defendants

(Bus. & Prof. Code § 17200 *et seq.*))

108. Plaintiff Betak incorporates his allegations in paragraphs 1-107, above, as if fully set forth herein.

109. Defendants Miftakhov, EMW, and Enel X have engaged in unlawful, unfair, and/or fraudulent business practices. These acts and practices include, but are not limited to:

a. Defendants Miftakhov and EMW's failure to identify Plaintiff Betak as an inventor in filing and prosecuting various patent applications, including the applications that resulted in the '941 and '277 Patents, despite their knowledge that he was one of the inventors of the inventions claimed in those patents, and their concealment of this omission from Betak;

b. Defendants Miftakhov and EMW's false and fraudulent promises to Plaintiff Betak that Betak would share in the proceeds resulting from his collaboration on the JuiceBox/JuiceNet project as a partial owner of the business that he worked without pay to build; and

c. Defendants Miftakhov's, EMW's, and Enel X's knowing and intentional efforts to acquire and transfer to Enel X patents on which Plaintiff Betak is named as an inventor, or should have been named as an inventor, without Betak's knowledge or consent;

d. Defendant Enel X's acquisition of patents that it knew or should have known failed to name all proper inventors, and without the assignment of the rights of all inventors to the acquired patents; and

e. Defendants Miftakhov's, EMW's and Enel X's failure to pay Plaintiff Betak anything for his work on the JuiceBox/JuiceNet project, the results of which were purportedly sold to Enel X as part of its acquisition of EMW.

110. On information and belief, the acts of Defendants Miftakhov, EMW, and Enel X were performed intentionally, in conscious or reckless disregard of Plaintiff Betak's rights, and designed to harm Betak for the benefit of Miftakhov and EMW.

111. As a direct and proximate result of the unfair competition described above, Defendants Miftakhov, EMW, and Enel X and their businesses, have benefited and will continue to benefit at the expense of Plaintiff Betak, who has suffered and will continue to suffer harm, in amounts not yet fully ascertained.

COUNT VII

(Constructive Trust Against All Defendants

(Cal. Civ. C. §§ 2223, 2224))

112. Plaintiff Betak incorporates his allegations in paragraphs 1-111, above, as if fully set forth herein.

113. As described herein, Defendants Miftakhov and EMW gained by fraud, mistake, and/or other wrongful acts intellectual property invented by Plaintiff Betak and secured patent rights thereto, and, on information and belief, continues to seek patent rights thereto, as well other

assets resulting from Plaintiff Betak's contributions for which he was not compensated. Defendants Miftakhov and EMW sold and/or otherwise transferred those intellectual property and other assets to Defendant Enel X without Plaintiff Betak's consent or authorization. Plaintiff Betak possesses rights to his inventions and intellectual property described and claimed in at least the '941 and '277 Patents, and in other currently pending applications. Plaintiff Betak has not assigned those rights to EMW, Enel X, or any other party. Enel X has publicly reported that it has acquired rights to the '941 and '277 Patents and other purported EMW intellectual property. On information and belief, a portion of the acquisition price of EMW includes amounts specifically associated with the intellectual property purportedly transferred to Enel X, including the '941 and '277 Patents and related currently-pending applications. Defendants Miftakhov and EMW have wrongfully detained the acquisition amounts attributable to intellectual property contributed by Plaintiff Betak. Defendant Enel X is wrongfully detaining purported patent rights that were not validly transferred to it by Defendant EMW.

114. Defendants would be unjustly enriched, at Plaintiff Betak's expense, if they were permitted to retain, use, and control the intellectual property, acquisition amounts, and other funds described above.

COUNT VIII

(Accounting Against All Defendants)

115. Plaintiff Betak incorporates his allegations in paragraphs 1-114, above, as if fully set forth herein.

116. On information and belief, by virtue of the wrongful acts described above, the assets and property that resulted from Plaintiff Betak's work on the JuiceBox/JuiceNet project, including but not limited to any revenues, profits, intellectual property, products, and other benefits that resulted therefrom, were improperly transferred to Defendant EMW, and then to Defendant Enel X and potentially elsewhere, all without any compensation to Plaintiff Betak.

117. The identity, amounts, and value of the transferred assets and property are unknown to Plaintiff Betak and, on information and belief, cannot be ascertained without an accounting.

RELIEF SOUGHT

WHEREFORE, Plaintiff Betak respectfully requests that the Court enter a judgment:

1. Declaring that Plaintiff Betak is an inventor of the '941 and '277 Patents;

2. Directing the Commissioner of the USPTO to issue a Certificate of Correction indicating that Plaintiff Betak was omitted as an inventor on the '941 and '277 Patents, and correcting that error by adding Betak as an inventor;

3. Alternatively to (2), ruling that the '941 and '277 Patents are invalid and unenforceable because the failure to identify Plaintiff Betak as an inventor was intentional and cannot be corrected;

4. Awarding Plaintiff Betak the actual damages caused by the misconduct of Defendants Miftakhov and EMW in an amount to be determined;

5. Awarding exemplary and punitive damages in favor of Plaintiff Betak and against Defendants in an amount to be determined;

6. Requiring restitution and disgorgement of funds resulting from the sale of EMW and transfer of assets from EMW to Enel X to which Plaintiff Betak is entitled from Defendants Miftakhov and EMW's unjust enrichment;

7. Imposing a constructive trust over proceeds from the acquisition of EMW by Enel X that are attributable to Plaintiff Betak's contributions and that are wrongfully being detained by Defendants Miftakhov and EMW, and requiring those amounts to be transferred to Plaintiff Betak.

8. Ordering that Defendants Miftakhov, EMW, and Enel X be required to account for all revenues, profits, equity interests, assets, property, or other benefits that resulted, in whole or in part, from Plaintiff Betak's work on the JuiceBox/JuiceNet project;

9. Awarding prejudgment and post-judgment interest as allowed pursuant to statutory and common law;

10. Awarding costs of suit incurred herein; and

11. Awarding such other and further relief as this Court may deem just and proper.

//

DEMAND FOR JURY TRIAL

Plaintiff Betak hereby demands a trial by jury on all issues so triable.

Dated: May 9, 2019

HOPKINS & CARLEY
A Law Corporation

By: */s/ Jason S. Angell*
Jason S. Angell
Christopher A. Hohn
Attorneys for Plaintiff
GEORGE BETAK, an individual

EXHIBIT A

US009987941B2

(12) **United States Patent**
Miftakhov et al.

(10) **Patent No.: US 9,987,941 B2**
(45) **Date of Patent: Jun. 5, 2018**

(54) SYSTEMS AND METHODS FOR LOCAL AUTONOMOUS RESPONSE TO GRID CONDITIONS BY ELECTRIC VEHICLE CHARGING STATIONS

(71) Applicant: **Electric Motor Werks, Inc.**, San Carlos, CA (US)

(72) Inventors: **Valery Miftakhov**, San Carlos, CA (US); **Alexander Gurzhi**, San Jose, CA (US); **Chris Edgette**, Oakland, CA (US); **Alan White**, Tuburon, CA (US)

(73) Assignee: **Electric Motor Werks, Inc.**, San Carlos, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days. days.

(21) Appl. No.: **14/853,955**

(22) Filed: **Sep. 14, 2015**

(65) **Prior Publication Data**

US 2016/0257214 A1 Sep. 8, 2016

Related U.S. Application Data

(60) Provisional application No. 62/050,147, filed on Sep. 14, 2014.

(51) **Int. Cl.**
H02J 7/00 (2006.01)
B60L 11/18 (2006.01)

(52) **U.S. Cl.**
CPC ***B60L 11/1844*** (2013.01); ***H02J 7/0027*** (2013.01); *Y02T 10/7055* (2013.01); *Y02T 90/168* (2013.01); *Y04S 30/12* (2013.01)

(58) **Field of Classification Search**
USPC 320/107-115
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0021213 A1*	1/2009	Johnson	B60L 11/005	320/109
2010/0013436 A1*	1/2010	Lowenthal	G06Q 30/04	320/109
2010/0201309 A1*	8/2010	Meek	B60L 11/1816	320/108
2015/0091506 A1*	4/2015	Hyde	B60L 11/1848	320/108

* cited by examiner

Primary Examiner — Binh Tat
(74) *Attorney, Agent, or Firm* — TransPacific Law Group; Pabel I. Pogodin, Esq.

(57) **ABSTRACT**

A system for generating a local autonomous response to a condition of an electric grid by electric vehicle charging stations, comprising: a first electricity meter for reading current, frequency, or voltage from a first electricity supply line to one electric vehicle charging station; a second electricity meter for reading current, frequency, or voltage from a second electricity supply line to all of the electric vehicle charging stations; a third electricity meter for reading current, frequency, or voltage from a third electricity line from one or more renewable generators; and an electric vehicle charging controller operatively coupled to the first electricity meter, the second electricity meter, the third electricity meter and the electric vehicle charging stations and operable to obtain readings from the first electricity meter, the second electricity meter and the third electricity meter and to control the electric vehicle charging stations based on the obtained readings.

20 Claims, 4 Drawing Sheets

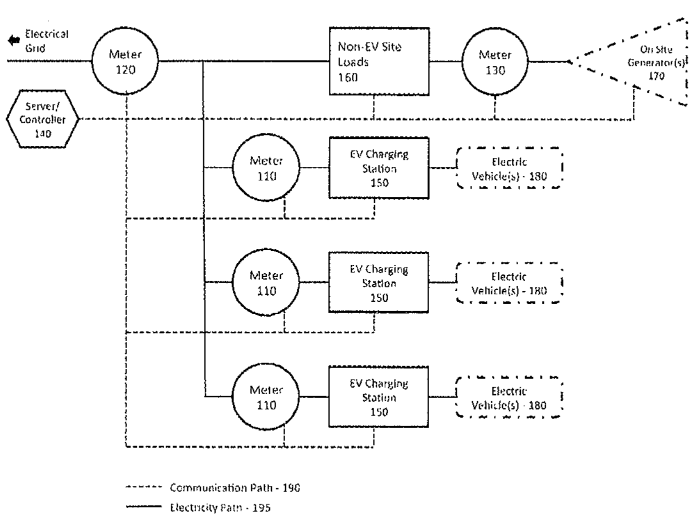
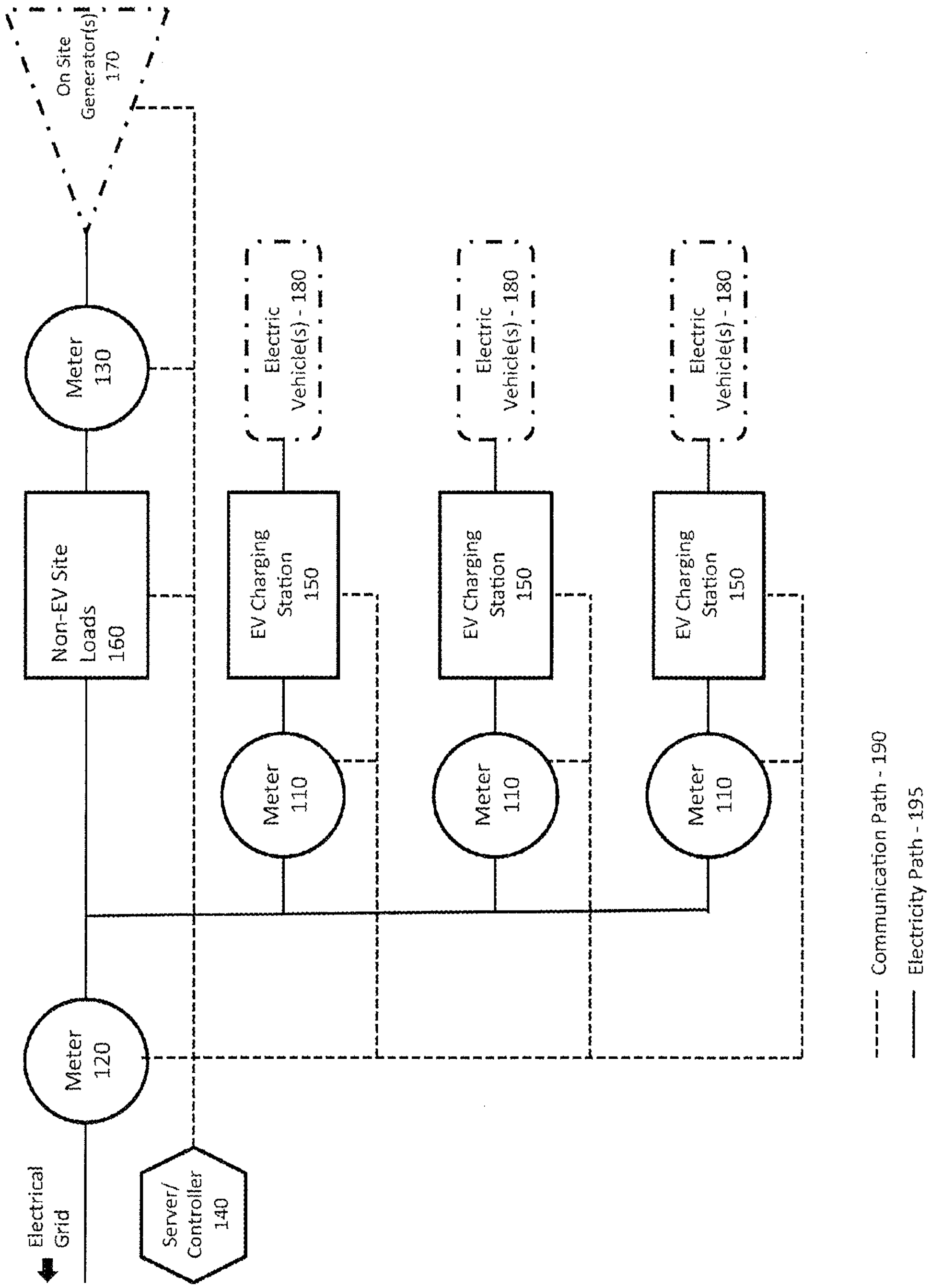


Figure 1


On Site Generator(s) 170
Meter 130
Non-EV Site Loads 160
Electric Vehicle(s) - 180
Electric Vehicle(s) - 180
Electric Vehicle(s) - 180
EV Charging Station 150
EV Charging Station 150
EV Charging Station 150
Meter 110
Meter 110
Meter 110
Meter 120
Electrical Grid
Server/ Controller 140
Communication Path - 190
Electricity Path - 195

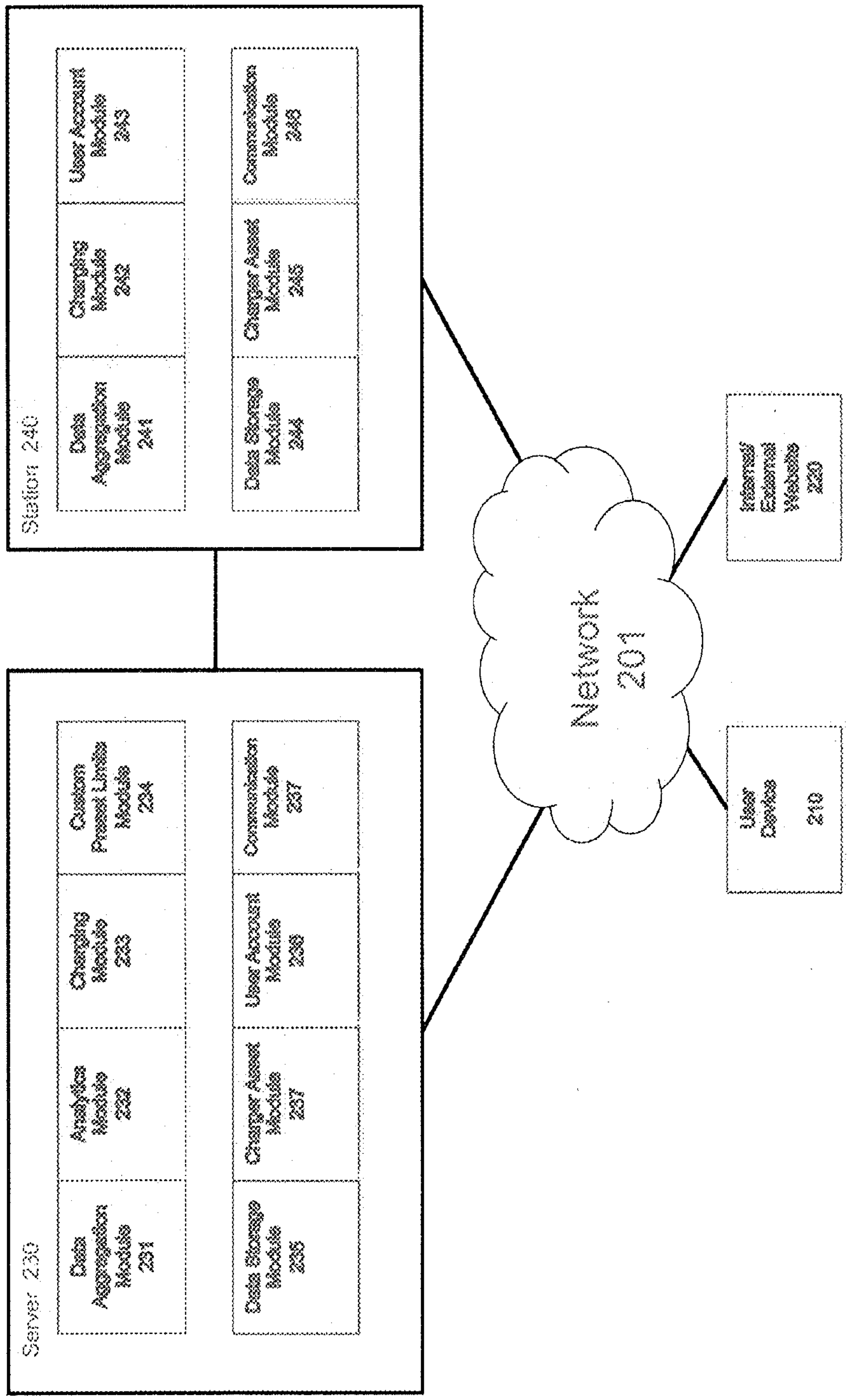

Station 240
Data Aggregation Module 241
Charging Module 242
User Account Module 243
Data Storage Module 244
Charger Asset Module 245
Communication Module 246
Server 230
Data Aggregation Module 231
Analytics Module 232
Charging Module 233
Custom Preset Limits Module 234
Data Storage Module 235
Charger Asset Module 237
User Account Module 236
Communication Module 237
Network 201
Internet/ External Website 220
User Device 210

Figure 2

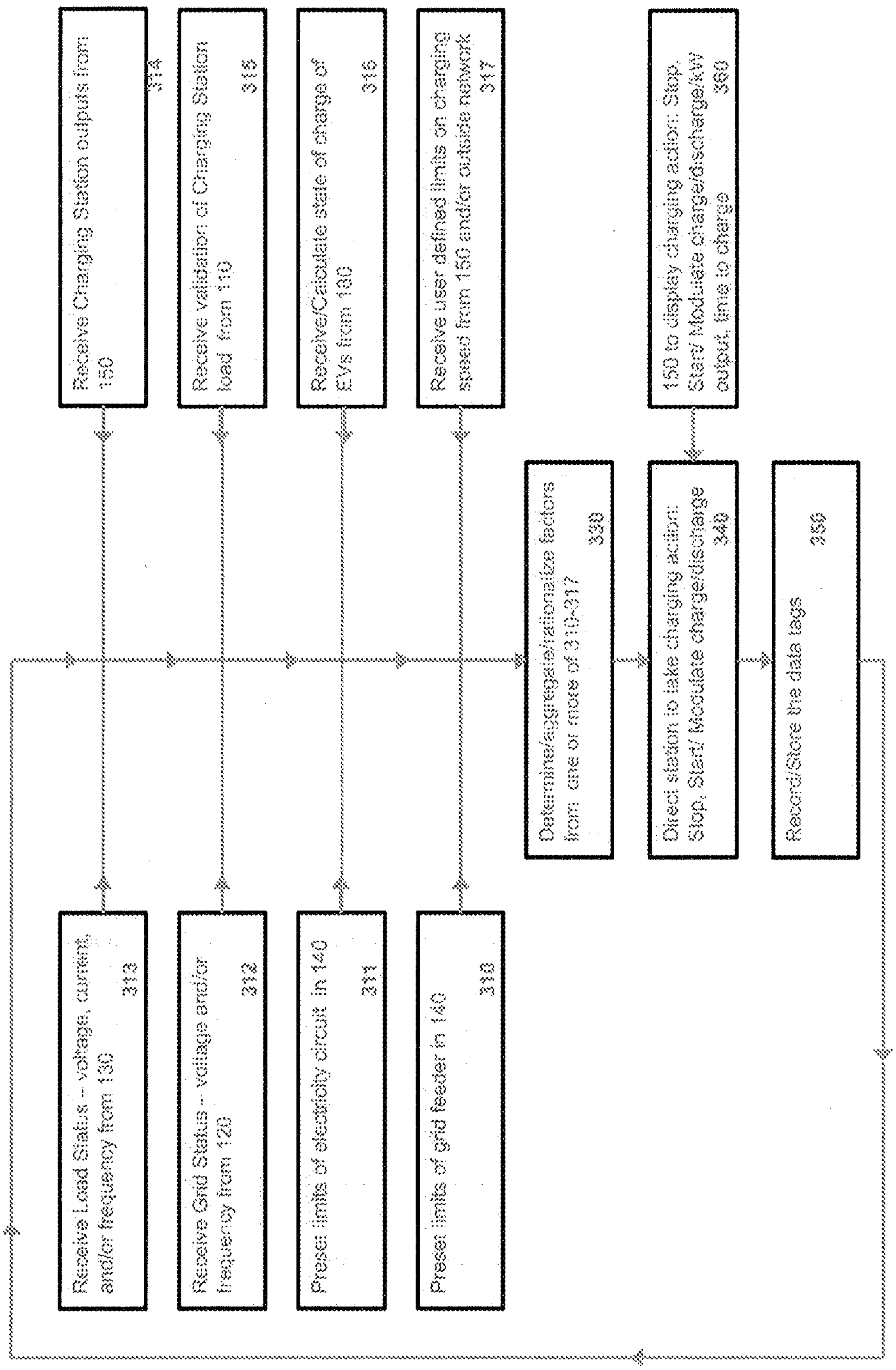
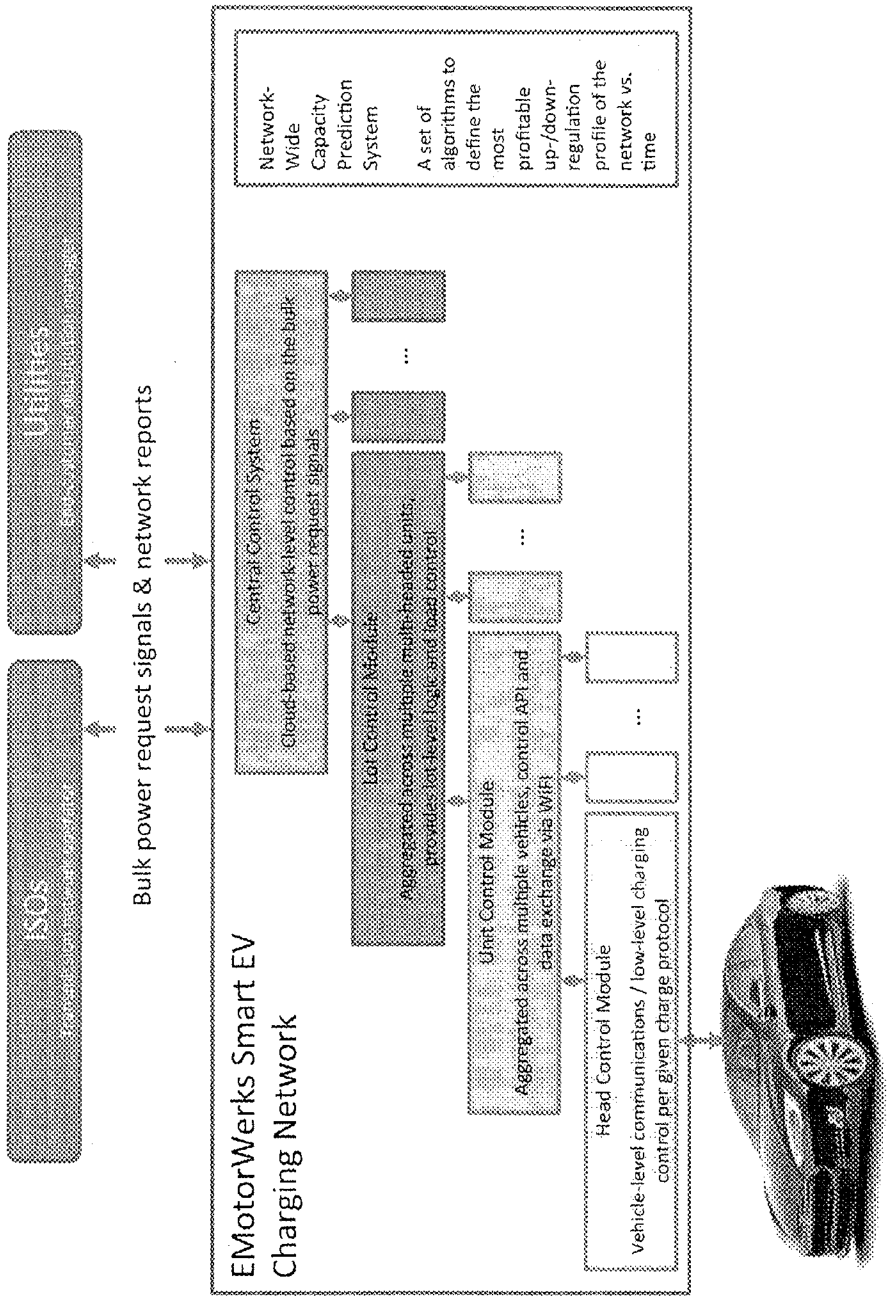

Receive Charging Station outputs from 150
314
Receive validation of Charging Station load from 110
315
Receive/Calculate state of charge of EVs from 130
316
Receive user defined limits on charging speed from 150 and/or outside network
317
150 to display charging action: Stop, Start/ Modulate charge/discharge/kW output, time to charge
360
Determine/aggregate/rationalize factors from one or more of 310-317
330
Direct station to take charging action: Stop, Start/ Modulate charge/discharge
340
Record/Store the data tags
350
Receive Load Status – voltage, current, and/or frequency from 130
313
Receive Grid Status – voltage and/or frequency from 120
312
Preset limits of electricity circuit in 140
311
Preset limits of grid feeder in 140
310

Figure 3

Figure 4


ISOs
Utilities
Bulk power request signals & network reports
EMotorWerks Smart EV Charging Network
Central Control System
Cloud-based network-level control based on the bulk power request signals
Lot Control Module
Aggregated across multiple multi-headed units, provides lot-level logic and load control
Unit Control Module
Aggregated across multiple vehicles, control API and data exchange via WiFi
Head Control Module
Vehicle-level communications / low-level charging control per given charge protocol
...
Network-Wide Capacity Prediction System
A set of algorithms to define the most profitable up-/down-regulation profile of the network vs. time

SYSTEMS AND METHODS FOR LOCAL AUTONOMOUS RESPONSE TO GRID CONDITIONS BY ELECTRIC VEHICLE CHARGING STATIONS

CROSS-REFERENCE TO RELATED PATENT APPLICATION

This regular U.S. patent application relies upon and claims the benefit of priority from U.S. provisional patent application No. 62/050,147, entitled "Grid Stabilization via a Large Distributed Collection of EV Charging Stations," filed on Sep. 14, 2014 and incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The disclosed embodiments relate in general to the field of electrical vehicle charging technology and power grid management and, more specifically, to systems and methods for local autonomous response to grid conditions by electric vehicle charging stations.

DESCRIPTION OF THE RELATED ART

There are close to 200,000 Plug-In Electric Vehicles (EVs) in the US alone today. This number is projected to grow to over 1 Million by 2017. In order to "re-fuel", every EV needs an "EVSE"—an EV Charging Station. A charging station supplies a certain amount of AC or DC power to the vehicle. The process is generally controlled by the vehicle that uses its internal Battery Management System's logic to determine the power to draw from the system—up to the total maximum power level allowed by the EVSE. The latter is normally set to a fixed level during EVSE manufacturing process.

A typical American EV consumes ~10-15 KWHr of energy every day to recharge its batteries—this amount of energy is sufficient to provide ~30-50 miles of daily driving (which is consistent with a US average commute distances).

A typical recharge time to transfer that amount of energy from the AC grid to the battery is 90 minutes. However, the amount of time available for such a recharge is generally over 23 hours during a typical 24-hour day. Moreover, there are at least two blocks of this time when a typical EV spends 8+ hours in one location. These locations are the home of the driver and her workplace. This difference between time available and actual time required for charging creates an opportunity to reduce the instantaneous charging power and still satisfy the driver's requirements for a full recharge for a day. E.g., if one were to spread the charging power uniformly over a 16-hour period (8 hours at work+8 hours at home), a typical EV can be recharged for a day at just 0.6 kW average power.

This ability to reduce instantaneous charging power can be utilized to modulate the instantaneous power drawn from a collection of EVs by modulating charging current via EV charging stations. Such modulation capability can then be used to provide various stabilization services to the Electrical Grid (e.g., Demand Management, Frequency Regulation, Peak Shaving, Economic Demand Response, etc.).

By the very nature of the Electrical Grid, Supply (electricity generation, in Watts) and Demand (electricity consumption, in Watts) have to be perfectly balanced at each point in time. Any imbalance creates undesirable effects in the Grid (e.g., deviation of the grid frequency from the set mean point—60 Hz in the USA).

To counteract this, Grid operators (ISOs, or independent system operators) operate a specialized marketplace where it buys an ability to modulate generation & demand in near-real-time (on time intervals of seconds to minutes).

Currently, electric vehicle supply equipment (EVSE, aka EV charging stations) does not provide automatic responses to local conditions or to the changing needs of the larger electric power grid. Services that might be provided by automatic dispatch include optimization and reliability functions for the local residential, industrial, or commercial site. They may also include local site functions that can help stabilize the wider power grid. Autonomous services are services that can be provided by an EVSE without directed dispatch by the equipment owner or operator.

Therefore, new and improved systems and methods for providing automatic responses to local conditions or to the changing needs of the larger electric power grid are needed.

SUMMARY OF THE INVENTION

The inventive methodology is directed to methods and systems that substantially obviate one or more of the above and other problems associated with conventional systems and methods for electrical vehicle charging and power grid management.

In accordance with one aspect of the embodiments described herein, there is provided a system for generating a local autonomous response to a condition of an electric grid by a plurality of electric vehicle charging stations, the system incorporating: a first electricity meter for reading current, frequency, or voltage from a first electricity supply line to one of the plurality of electric vehicle charging stations; a second electricity meter for reading current, frequency, or voltage from a second electricity supply line to all of the plurality of electric vehicle charging stations; a third electricity meter for reading current, frequency, or voltage from a third electricity line from one or more renewable generators; and an electric vehicle charging controller operatively coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations and operable to obtain readings from the first electricity meter, the second electricity meter and the third electricity meter and to control at least one of the plurality of electric vehicle charging stations based on the obtained readings.

In one or more embodiments, the electric vehicle charging controller comprises a server disposed on a computer network and wherein the electric vehicle charging controller is coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations via the computer network.

In one or more embodiments, the system further comprises a remote server executing a vehicle charge control application.

In one or more embodiments, the electric vehicle charging controller comprises an internal logic to determine an appropriate charging output in response to the obtained readings.

In one or more embodiments, the electric vehicle charging controller is operable to direct the plurality of electric vehicle charging stations to vary charging load to one or more electric vehicles based upon the internal logic.

In one or more embodiments, the electric vehicle charging controller is configured to control one or more electric power generators based upon the internal logic.

In one or more embodiments, the electric vehicle charging controller comprises a local storage for storing custom

presets relating to a local circuit or a local utility feeder, a frequency response requirements, or CVR requirements.

In one or more embodiments, each of the plurality of electric vehicle charging stations varies rate of charge or discharge according commands received from the electric vehicle charging controller.

In one or more embodiments, each of the plurality of electric vehicle charging stations is configured to receive vehicle owner preferences with respect to vehicle charging.

In one or more embodiments, each of the plurality of electric vehicle charging stations is configured to display to a user or to output to an outside application:

i. a real time charging information;

ii. a vehicle owner charging preferences;

iii. alerts regarding a charging status;

iv. a vehicle state of charge; and

v. and estimated time to completion of charge.

In accordance with one aspect of the embodiments described herein, there is provided a method for generating a local autonomous response to a condition of an electric grid by a plurality of electric vehicle charging stations, the method comprising: providing a first electricity meter for reading current, frequency, or voltage from a first electricity supply line to one of the plurality of electric vehicle charging stations; providing a second electricity meter for reading current, frequency, or voltage from a second electricity supply line to all of the plurality of electric vehicle charging stations; providing a third electricity meter for reading current, frequency, or voltage from a third electricity line from one or more renewable generators; and providing an electric vehicle charging controller operatively coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations and operable to obtain readings from the first electricity meter, the second electricity meter and the third electricity meter and to control at least one of the plurality of electric vehicle charging stations based on the obtained readings.

In one or more embodiments, the electric vehicle charging controller comprises a server disposed on a computer network and wherein the electric vehicle charging controller is coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations via the computer network.

In one or more embodiments, the method further comprises providing a remote server executing a vehicle charge control application.

In one or more embodiments, the electric vehicle charging controller comprises an internal logic to determine an appropriate charging output in response to the obtained readings.

In one or more embodiments, the electric vehicle charging controller is operable to direct the plurality of electric vehicle charging stations to vary charging load to one or more electric vehicles based upon the internal logic.

In one or more embodiments, the electric vehicle charging controller is configured to control one or more electric power generators based upon the internal logic.

In one or more embodiments, the electric vehicle charging controller comprises a local storage for storing custom presets relating to a local circuit or a local utility feeder, a frequency response requirements, or CVR requirements.

In one or more embodiments, each of the plurality of electric vehicle charging stations varies rate of charge or discharge according commands received from the electric vehicle charging controller.

In one or more embodiments, each of the plurality of electric vehicle charging stations is configured to receive vehicle owner preferences with respect to vehicle charging.

In one or more embodiments, each of the plurality of electric vehicle charging stations is configured to display to a user or to output to an outside application:

vi. a real time charging information;

vii. a vehicle owner charging preferences;

viii. alerts regarding a charging status;

ix. a vehicle state of charge; and

x. and estimated time to completion of charge.

Additional aspects related to the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. Aspects of the invention may be realized and attained by means of the elements and combinations of various elements and aspects particularly pointed out in the following detailed description and the appended claims.

It is to be understood that both the foregoing and the following descriptions are exemplary and explanatory only and are not intended to limit the claimed invention or application thereof in any manner whatsoever.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification exemplify the embodiments of the present invention and, together with the description, serve to explain and illustrate principles of the inventive technique. Specifically:

FIG. **1** illustrates an exemplary embodiment of a logical diagram of a distributed system configuration based on which the functionality described herein may be deployed.

FIG. **2** illustrates exemplary internal data flows between the components shown in the logical diagram of FIG. **1**.

FIG. **3** illustrates an exemplary block diagram of automated dispatch by a server or station.

FIG. **4** illustrates an exemplary embodiment of a grid stabilization via a large distributed collection of EV charging stations.

DETAILED DESCRIPTION

In the following detailed description, reference will be made to the accompanying drawing(s), in which identical functional elements are designated with like numerals. The aforementioned accompanying drawings show by way of illustration, and not by way of limitation, specific embodiments and implementations consistent with principles of the present invention. These implementations are described in sufficient detail to enable those skilled in the art to practice the invention and it is to be understood that other implementations may be utilized and that structural changes and/or substitutions of various elements may be made without departing from the scope and spirit of present invention. The following detailed description is, therefore, not to be construed in a limited sense.

In accordance with one aspect of the embodiments described herein, there are provided a novel system and method in which an aggregated system of controllable EV charging stations exploits an ability to modulate charging power rates to provide such services to the grid operators.

In accordance with another aspect of the embodiments described herein, there are provided systems and methods for generating automatic responses to local conditions or to the changing needs of the larger electric power grid.

Embodiments of the described invention provide several important services to the local site as well as the wider electric grid, through local automatic response of an EVSE. In one or more embodiments, when a plug in vehicle is charging, the EVSE can provide several automatic services, each of which provides value in different ways. Services and their automatic responses include one or more of the following functionalities, which should note be interpreted in a limited sense:

1. Dynamic load sharing. With dynamic load sharing, several EVSEs automatically coordinate to optimize an electrical circuit. Without dynamic load sharing, the number of EVSEs that may be added to a circuit and/or feeder is capped by the maximum current rating of all EVSEs, such that the combined maximum current draw of all EVSEs operating simultaneously at full charge will never exceed the capacity of the circuit on which they are installed. This limits the number of EVSEs that can be installed on a circuit. If more EVSEs are desired on a circuit, the entire circuit must be upgraded, at significant expense. The vast majority of the time, all EVSEs on a circuit are not needed, as vehicles are either not plugged in to every EVSE, or the vehicles that are plugged in have already been fully charged. The limitation on the number of EVSEs on a circuit can be solved by enabling individual or groups of EVSEs to automatically reduce their charging current in cases where most or all EVSEs are operating simultaneously, such that the aggregated group of EVSEs never exceed the current carrying capacity of the circuit. This invention includes automatic charging current reduction with awareness of the circuit limits and the aggregated charging current of other EVSEs in the group.

2. Local load control. This capability is similar to Dynamic Load Sharing, wherein individual EVSEs and/or groups of EVSEs automatically reduce their charging loads to optimize the loads on the site. The difference is that, in Local Load Control, individual and/or groups of EVSEs can automatically reduce individual charging loads in coordination with other site loads (e.g. air conditioning units, lighting), to maintain an overall site load lower than the limit of the electrical feeder to the site. The benefit is that more EVSEs may be added to a site than would otherwise be possible under the existing feeder limits. This capability may also be used to reduce customer retail demand.

3. Load Coordination with On Site Renewables: With this capability, EVSE loads may be automatically varied based upon the output of on site renewable generators. These generators may include, but are not limited to, on site solar, wind, biogas, fuel cells, or geothermal generators. Automated coordination of EVSEs may allow increased capture of renewable energy, reduced customer electric bills, and/or reduced current flow to or from the site, as needed to optimize the overall customer electrical load and electric bill savings.

4. Conservation Voltage Reduction: Conservation Voltage Reduction (CVR) is a technology used for reducing energy and peak demand. CVR is implemented upstream of end service points in the distribution system so that the efficiency benefits are realized by consumers and the electric distributor. This invention proposes adding automated CVR capabilities to EVSEs to provide local benefits to the site and electric distributor hosting the charging stations.

5. Frequency Response: With this capability, EVSEs automatically senses a frequency drop on the grid and cease charging to help stabilize grid frequency. EVSEs will represent significant grid loads in the future electricity system, so the capability to automatically and quickly reduce charging load in response to grid frequency can provide great benefits to the grid at a very low cost.

In one or more embodiments, individual EVSEs and/or groups of EVSEs are configured to measure any or all of the following parameters: grid frequency, grid voltage, customer electrical load, individual EVSE load, and aggregated EVSE load. In one or more embodiments, individual EVSEs and/or groups of EVSEs with on board logic to respond to any or all of the above measurements. On-board logic may seek to optimize supply current to any or all of the following functions: dynamic load sharing, load coordination with on site renewables, conservation voltage reduction, and/or frequency response. In one or more embodiments, individual EVSEs and/or groups of EVSEs are provided with on-board capability to vary their supply current to plug-in electric vehicles in response to the on-board logic described above.

FIG. **1** illustrates an exemplary embodiment of a distributed system configuration based on which the functionality described herein may be deployed. The elements shown in FIG. **1** are described in detail below.

Element **110**—Meter: Electricity meter(s) for reading current, frequency, and/or voltage from the electricity line to an individual EV charging station. Capable of returning meter readings via communication path to one or more EV charging station(s). This meter may be integrated into the EV charging station.

Element **120**—Meter: Electricity meter for reading current, frequency, and/or voltage from the electricity line to the entire site. Capable of returning meter readings via communication path to one or more EV charging station(s). This meter is not required for all aspects of this invention.

Element **130**—Meter: Electricity meter(s) for reading current, frequency, and/or voltage from the electricity line from one or more on site renewable generators. Capable of returning meter readings via communication path to one or more EV charging station(s). This meter is not required for all aspects of this invention.

Element **140**—Master Controller/Server: An electric vehicle charging controller with the following features:

a. Connections to various electrical meters on site and the capacity to read those meters;
b. Connection to user application hosted on outside server and/or station controls;
c. Logic to determine appropriate charging output in response to one or more meter readings;
d. Capacity to direct EV charging stations (**150**) to vary charging load to one or more electric vehicles based upon internal logic;
e. Capacity to incorporate and store custom presets regarding the local circuit and/or utility feeder, frequency response requirements, and/or CVR requirements.

It should be noted that this server functionality could potentially be integrated into one or more of the EV charging stations, see Element **150**.

Element **150**—EV Charging Station with Slave Controls: An electric vehicle charging station with the following features:

a. Capacity to vary charge and discharge according to internal controls, application directions;
b. Capacity to receive vehicle owner preferences on station or via outside application;
c. Capacity to display or output to outside app one or more of the following:
   i. Real time charging information;
   ii. Vehicle owner charging preferences;
   iii. Alerts regarding charging status;

iv. Vehicle state of charge; and/or

v. Estimated time to completion of charge.

Element **160**—Non-EV Site Loads: Non-EV Site loads comprise loads such as air conditioning, lighting, plug loads, etc. It should be noted that these loads may be independently metered and/or controlled by EV charging station autonomous logic controls.

Element **170**—On Site Generator(s): Renewable and/or non-renewable generators may be located behind or in front of site loads. They may be controllable by EV charging station logic.

Element **180**—Electric Vehicle(s): One or more electric vehicles intermittently connected to the EV charging station. These vehicles may exist in various states of charge.

Element **190**—Communication Path: Path between meters, EV charging stations, load controls, on site generators, and/or non-EV site loads. This communication path may be implemented using any now known or later developed interconnect.

Element **195**—Electricity Path: Conductors transmitting electrical energy from the grid to various site loads and generators.

FIG. **2** illustrates exemplary internal data flows between the components shown in the logical diagram of FIG. **1**.

FIG. **3** illustrates an exemplary block diagram of automated dispatch by server or station.

1. Vehicle-level Charging Control System: a system to implement a controllable charging rate using the appropriate standard charging protocols—at a single vehicle level (named "Head"-level in the rest of this document). This system is abbreviated as HCM (head control module) in the rest of this document.

a. A sub-system providing a low-level charging protocol implementation (analog for J1772 SAE standard for Level 2 charging, analog+digital for CHAdeMO JST standard for Level 3 charging, etc.)

b. A sub-system providing control API layer to allow the HCM to modulate the rate of charge of the vehicle

c. A sub-system providing physical control interface (such as SPI, CANbus, etc.) to allow information transfer from and to the HCM.

2. Unit-level Charging Control System: a system & algorithm to adjust charging rates of individual charging heads to optimize the charging outcome given all constraints.

a. A Unit-level system is an aggregation of Heads in immediate physical proximity of each other (generally within a few meters—a distance when a wired information connection can be effectively made).

b. A Unit-level system is generally composed of a physically integrated set of Heads, often in one enclosure.

c. A Unit-level system generally has a single electrical feed powering multiple Heads together with the main Unit Control Module (UCM).

i. In one embodiment, a simple 240V 40 A service is deployed to power a unit with six Heads, thereby reducing the amount of labor and material by a factor of 3-6 relative to a single—/dual-head station deployment.

d. A sub-system to gather charging occasion information based on: i. Vehicle type.

1. identification of the vehicles based on the captured image of the vehicle with on-board camera.

2. identification of the vehicles based on the characteristic form of the charging current ramp-up/ramp-down.

3. identification of the vehicles based on the maximum amount of power drawn by the vehicle's charger.

User Profile (if Properly Authenticated)

1. using over-time heuristics to predict likely state of charge of the user's vehicle when he/she arrives at the charging station (e.g., a person normally has the same commute distance every day, hence we could measure the energy intake on one day and then assume the same for following days)

iii. Historical load profile vs time at the particular UCM (minute-by-minute)

e. A sub-system that converts these informational elements into an estimate of how much flexibility it has to modulate the charging current for the vehicles that are plugged in to the station

f. UCM-level system to be connected to both Head-level and Lot-level systems via a physical network layer for bi-directional information transfer. The individual modules would then be addressed using a specialized addressing scheme.

g. Note that Head-level and UCM-level control can be implemented in the same physical device when there is only one Head installed in a UCM (as will be the case in a residential installation).

3. Lot-level Charging Control System: a system & algorithm to adjust Unit-level charging control decisions based on the Lot-level charging context. Abbreviated as LCD (Lot Control Module) in this document.

a. A Lot-level system is an aggregation of multiple UCMs in physical proximity to each other (generally within the range of WiFi connectivity)

b. Context to be based on (including but not limited to):

i. Total amount of power available from the Lot-level power feed (e.g., power supply capacity for the building equipped with a number of UCMs)

ii. Historical load profile vs time at the particular Lot

c. Lot-level system to be connected to both Unit-level and Central Load Control Systems via a wireless network layer for bi-directional information transfer

d. Note that Lot-level and UCM-level control can be implemented in the same physical device when there is only one UCM installed in a Lot (as will be the case in a residential installation).

4. Central Load Control System: a system to receive control signals from the Grid Operators and convert them into the set of Lot-level control commands across the EV Station network.

a. A sub-system to receive external control signals from the Grid Operators.

b. A sub-system to execute automatic negotiations between the central load control system and each of the UCMs.

i. UCMs constantly report their modulation capacity to the Central System based on the Charging Occasion Information.

1. Optimal modulation capacity—capacity that will result in the 95% confidence level in achieving user-level SLA (charge complete by the time user plugs out)

2. Maximum modulation capacity—maximum amount of power that can be drawn by the EVs plugged into the station at the moment.

The central system determines the amount of desired demand modulation

1. Based on the external control signals and modulation capacity information gathered from the appropriate part of the network.

2. The system makes an intelligent risk management decision to deviate from the optimal modulation level to maximize total potential revenues while containing user SLA risks.

5. Robust Network Management Approach: a process and system design to perform all technical system management tasks.

a. A set of connection protocols to link all sub-systems together and control them in a unified fashion to achieve the desired overall functionality:

Head-level to UCM-level via hardwired connection for security (e.g., SPI bus)

UCM-level to Lot Management level via encrypted WiFi

Lot Management level to Central Load Control System via encrypted GPRS (cellular link)

b. A software and hardware capability to update station's firmware over the air, without the need for field visits

c. A sub-system to monitor station's health status remotely based on direct reports from UCM-/Lot-level systems and based on analysis of in-period charging statistics with respect to the historical baselines

6. Predictive load modeling software: a distributed computer program designed to predict network's capacity to respond to load management signals at any time

a. Outputs

i. Utility-ready prediction of the Down-regulation and Up-regulation capacity by pre-defined load aggregation areas (down-regulation=ability to REDUCE the load, up-regulation=ability to INCREASE the load).

ii. Current state+prediction of future capacity in 1-minute intervals for 60 minutes ahead.

b. Inputs

i. User-supplied data

ii. Network-supplied data

1. Real-time

2. Historical

iii. Additional context data

c. Modeling approach

i. Map all Units onto the topology of the grid network chosen by the partner utilities.

1. Multiple utilities/topologies can be used to create multiple load models.

2. Further text describes modeling approach at the individual node level of such a topology.

3. One example of a node can be a SLAP-2 area (Sub-Load Aggregation Point) in San Francisco Bay Area, covering ~1 million population across ~300,000 households, with total average electricity consumption of ~500 MW (commercial and residential) ii. Build up the prediction of the power-distribution-node-level down- and up-regulation capacity by aggregating head-level predictions and applying constraints from each aggregation level of the network

1. For each head, model minimum and maximum permissible charging current. Initial elements of the approach include:

a. Associate each head with a specific vehicle

i. In residential installations, association is generally trivial

1. User will supply vehicle data at the time of installation/sign-up.

2. One head is used with the same vehicle vast majority of the time

3. In case when households have more than one vehicle, the association is still relatively simple by using ramp-up signatures and max charging power

4. As a result, Vehicle ID profile structure is built by the unit

In commercial installations, association is more complex given higher mobility of the vehicles across charging spots. Therefore, additional data will be collected to assist association

1. Unit Control Module will be equipped with a video camera that will take snapshots of all vehicles plugged in

2. UCM software will then pre-process the images into vehicle ID profile elements such as license plate number, color, make and model (based on shape of the car)

3. Vehicle ID profile is then augmented with additional vehicle ID data based on electrical parameters of the charging session—such as power ramp rate on plug-in and max power achieved

Vehicle ID Profiles will then be transmitted along with the Lot ID to the Central Control System (CCS) where they will be matched against known vehicle database (at the Lot level) and the association will be finalized for each charging session

b. Using historical plug-in/plug-out/charge duration times, build a 'Vehicle Availability & Energy Profile' for each Head-Vehicle combination

i. This will allow the system to understand the typical patterns of use for the vehicle.

ii. The pattern data will include

1. Probability of the Vehicle availability at the Head location by minute of day —separately for each day of the week

2. Probability distribution of the depth of discharge of the Vehicle at the moment of plug-in by time of day of plug-in and the number of plug-ins prior to that

iii. These patterns of use will then be factored into the Head-level capacity prediction algorithm. The output of such algorithm will be Capacity=f(time of day, day of week, number of plug-ins before this one during same day). Capacity will be expressed in the units of kWHr.

iv. These patterns will also be used to create a prediction of Demand which will attempt to approximate the amount of energy needed to be in the Vehicle's battery at any point in time in order to satisfy the Vehicle's use patterns.

1. For example, if the vehicle is usually unplugged at 8 pm for a 10-mile trip on Fridays (e.g., to go to the Movies), spending 3 KWHrs for that trip, Demand (8 pm) will be =3 KWHrs

v. Finally, an estimate of the energy content in the Vehicle battery will be made and distribution of that Content will be created vs time

c. These capacity, content, and demand predictions will then be combined with the Vehicle-level information on the maximum charging power to produce a distribution of the minimum and maximum charge current that is likely available at a given Head-Vehicle combo at any given time for the next 60 minutes

i. Minimum charge current will be defined by the need to meet demand at the next plug-out moment

ii. Maximum charge current will be defined by the charger rating

2. These min/max current predictions will then be combined with restrictions from the higher-level network tiers to arrive at the adjusted Head Regulation Ability (2 numbers will be provided—one for up-regulation, one—for down-regulation)

a. Unit-level module will apply constraints on the total power available to all Heads connected to the UCM

In cases of multi-headed units with SUM(head power rating)>power rating of the Unit connection to the grid, max current available to each Head will be reduced

The reduction for each specific Head will depend on the vehicle demand profile and energy content. For vehicles with smaller energy reserves (=higher probability of not meeting demand), max current will be reduced less—at the expense of the other Heads present on this unit.

These adjustments will be recalculated any time Head-Vehicle configurations change at the unit level (e.g., one car leaves)

b. Lot-level module will apply constraints on the total power available to all Units connected to the LCM—using similar logic described for UCM-level adjustment

c. The resulting fully adjusted Head-level min/max current levels will be combined with predicted regulation demand to produce the Most Beneficial Charge Rate for each head

The initial MBCR will be set to a mid-point between min and max permissible charge rates. It will then be adjusted based on the predicted regulation demand

If the regulation requests at that particular time mostly expected to be down-regulation requests (i.e. requests to increase the load), the system will REDUCE MBCR to provide more room for increasing the charge current

Conversely, if the reg requests are mostly expected to be up-regulation requests, the system will INCREASE MBCR

d. The difference between min charge rate and MBCR and MBCR and max charge rate will be calculated and designated as UP-REGULATION CAPACITY and DOWN-REGULATION CAPACITY

3. These adjusted head-level regulation capacities will then be combined at the power-distribution-network-node-level to produce aggregated network regulation capacities

4. These capacities will then be used to announce EV Charging Network capability to the Utilities at any point in time

Finally, it should be understood that processes and techniques described herein are not inherently related to any particular apparatus and may be implemented by any suitable combination of components. Further, various types of general purpose devices may be used in accordance with the teachings described herein. It may also prove advantageous to construct specialized apparatus to perform the method steps described herein. The present invention has been described in relation to particular examples, which are intended in all respects to be illustrative rather than restrictive.

Moreover, other implementations of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. Various aspects and/or components of the described embodiments may be used singly or in any combination in systems and methods for generating automatic responses to local conditions or to the changing needs of the larger electric power grid. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A system for generating a local autonomous response to a condition of an electric grid by a plurality of electric vehicle charging stations, the system comprising:

a. a first electricity meter for reading current, frequency, or voltage from a first electricity supply line to one of the plurality of electric vehicle charging stations;

b. a second electricity meter for reading current, frequency, or voltage from a second electricity supply line to all of the plurality of electric vehicle charging stations;

c. a third electricity meter for reading current, frequency, or voltage from a third electricity line from one or more renewable generators; and

d. an electric vehicle charging controller operatively coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations and operable to obtain readings from the first electricity meter, the second electricity meter and the third electricity meter and to control at least one of the plurality of electric vehicle charging stations based on the obtained readings.

2. The system for generating a local autonomous response to a condition of an electric grid of claim **1**, wherein the electric vehicle charging controller comprises a server disposed on a computer network and wherein the electric vehicle charging controller is coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations via the computer network.

3. The system for generating a local autonomous response to a condition of an electric grid of claim **1**, further comprising a remote server executing a vehicle charge control application.

4. The system for generating a local autonomous response to a condition of an electric grid of claim **1**, wherein the electric vehicle charging controller comprises an internal logic to determine an appropriate charging output in response to the obtained readings.

5. The system for generating a local autonomous response to a condition of an electric grid of claim **4**, wherein the electric vehicle charging controller is operable to direct the plurality of electric vehicle charging stations to vary charging load to one or more electric vehicles based upon the internal logic.

6. The system for generating a local autonomous response to a condition of an electric grid of claim **4**, wherein the electric vehicle charging controller is configured to control one or more electric power generators based upon the internal logic.

7. The system for generating a local autonomous response to a condition of an electric grid of claim **1**, wherein the electric vehicle charging controller comprises a local storage for storing custom presets relating to a local circuit or a local utility feeder, a frequency response requirements, or CVR requirements.

8. The system for generating a local autonomous response to a condition of an electric grid of claim **1**, wherein each of the plurality of electric vehicle charging stations varies rate of charge or discharge according commands received from the electric vehicle charging controller.

9. The system for generating a local autonomous response to a condition of an electric grid of claim **1**, wherein each of the plurality of electric vehicle charging stations is configured to receive vehicle owner preferences with respect to vehicle charging.

10. The system for generating a local autonomous response to a condition of an electric grid of claim **1**, wherein each of the plurality of electric vehicle charging stations is configured to display to a user or to output to an outside application:

i. a real time charging information;

ii. a vehicle owner charging preferences;

iii. alerts regarding a charging status;

iv. a vehicle state of charge; and

v. and estimated time to completion of charge.

11. A method for generating a local autonomous response to a condition of an electric grid by a plurality of electric vehicle charging stations, the method comprising:

a. providing a first electricity meter for reading current, frequency, or voltage from a first electricity supply line to one of the plurality of electric vehicle charging stations;

b. providing a second electricity meter for reading current, frequency, or voltage from a second electricity supply line to all of the plurality of electric vehicle charging stations;

c. providing a third electricity meter for reading current, frequency, or voltage from a third electricity line from one or more renewable generators; and

d. providing an electric vehicle charging controller operatively coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations and operable to obtain readings from the first electricity meter, the second electricity meter and the third electricity meter and to control at least one of the plurality of electric vehicle charging stations based on the obtained readings.

12. The method for generating a local autonomous response to a condition of an electric grid of claim 11, wherein the electric vehicle charging controller comprises a server disposed on a computer network and wherein the electric vehicle charging controller is coupled to the first electricity meter, the second electricity meter, the third electricity meter and the plurality of electric vehicle charging stations via the computer network.

13. The method for generating a local autonomous response to a condition of an electric grid of claim 11, further comprising providing a remote server executing a vehicle charge control application.

14. The method for generating a local autonomous response to a condition of an electric grid of claim 11, wherein the electric vehicle charging controller comprises an internal logic to determine an appropriate charging output in response to the obtained readings.

15. The method for generating a local autonomous response to a condition of an electric grid of claim 14, wherein the electric vehicle charging controller is operable to direct the plurality of electric vehicle charging stations to vary charging load to one or more electric vehicles based upon the internal logic.

16. The method for generating a local autonomous response to a condition of an electric grid of claim 14, wherein the electric vehicle charging controller is configured to control one or more electric power generators based upon the internal logic.

17. The method for generating a local autonomous response to a condition of an electric grid of claim 11, wherein the electric vehicle charging controller comprises a local storage for storing custom presets relating to a local circuit or a local utility feeder, a frequency response requirements, or CVR requirements.

18. The method for generating a local autonomous response to a condition of an electric grid of claim 11, wherein each of the plurality of electric vehicle charging stations varies rate of charge or discharge according commands received from the electric vehicle charging controller.

19. The method for generating a local autonomous response to a condition of an electric grid of claim 11, wherein each of the plurality of electric vehicle charging stations is configured to receive vehicle owner preferences with respect to vehicle charging.

20. The method for generating a local autonomous response to a condition of an electric grid of claim 11, wherein each of the plurality of electric vehicle charging stations is configured to display to a user or to output to an outside application:

i. a real time charging information;

ii. a vehicle owner charging preferences;

iii. alerts regarding a charging status;

iv. a vehicle state of charge; and

v. and estimated time to completion of charge.

* * * * *

EXHIBIT B

US010025277B2

(12) **United States Patent**
Miftakhov et al.

(10) **Patent No.: US 10,025,277 B2**
(45) **Date of Patent: Jul. 17, 2018**

(54) **SYSTEMS AND METHODS FOR ELECTRICAL CHARGING LOAD MODELING SERVICES TO OPTIMIZE POWER GRID OBJECTIVES**

(71) Applicant: **Electric Motor Werks, Inc.**, San Carlos, CA (US)

(72) Inventors: **Valery Miftakhov**, San Carlos, CA (US); **Alexander Gurzhi**, San Jose, CA (US); **Chris Edgette**, Oakland, CA (US); **Alan White**, Tiburon, CA (US)

(73) Assignee: **Electric Motor Werks, Inc.**, San Carlos, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 18 days.

(21) Appl. No.: **15/004,976**

(22) Filed: **Jan. 24, 2016**

(65) **Prior Publication Data**

US 2017/0017213 A1 Jan. 19, 2017

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/853,955, filed on Sep. 14, 2015.

(Continued)

(51) **Int. Cl.**
H02J 7/00 (2006.01)
G05B 13/04 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC ***G05B 13/041*** (2013.01); ***B60L 11/1809*** (2013.01); ***G05F 1/66*** (2013.01);

(Continued)

(58) **Field of Classification Search**
USPC 320/106-115
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0133337 A1* 5/2012 Rombouts H02J 3/32 320/155
2013/0179061 A1* 7/2013 Gadh B60L 11/1842 701/123
2014/0062401 A1* 3/2014 Gadh B60L 11/1838 320/109

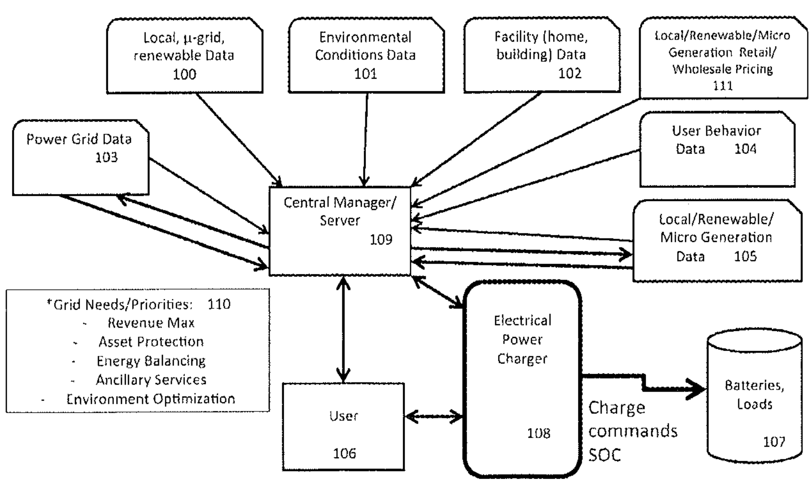
* cited by examiner

Primary Examiner — Binh Tat
(74) *Attorney, Agent, or Firm* — TransPacific Law Group; Pavel I. Pogodin, Esq.

(57) **ABSTRACT**

A system configured to receive and automatically analyze various types of information, including, without limitation, information from energy generators, information from non-generation resources, information on the facility status, information on user behavior, information on user's short-term energy needs (e.g. over-ride any algorithm due to immediate charging need), information on renewable generation, including, without limitation, solar, wind, biomass and/or hydro, and information on environmental conditions including, without limitation, barometric pressure, temperature, ambient light intensity, humidity, air speed, and air quality. In one or more embodiments, a sole novel charging station or selected, aggregated groupings of the aforesaid novel charging stations are configured to start, modulate or stop charging, or start, modulate (down) or stop discharging over specific time intervals based on the electrical grid needs as automatically determined based on the totality of the received diverse information. To this end, a system and an associated method are provided to perform complete electrical charging load modeling to optimize power grid objectives.

20 Claims, 5 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 62/050,147, filed on Sep. 14, 2014.

(51) **Int. Cl.**

G07F 15/00	(2006.01)
G05F 1/66	(2006.01)
B60L 11/18	(2006.01)

(52) **U.S. Cl.**
CPC ***G07F 15/005*** (2013.01); ***H02J 7/0027*** (2013.01); *G05B 2219/2637* (2013.01); *Y02P 80/21* (2015.11)

Figure 1

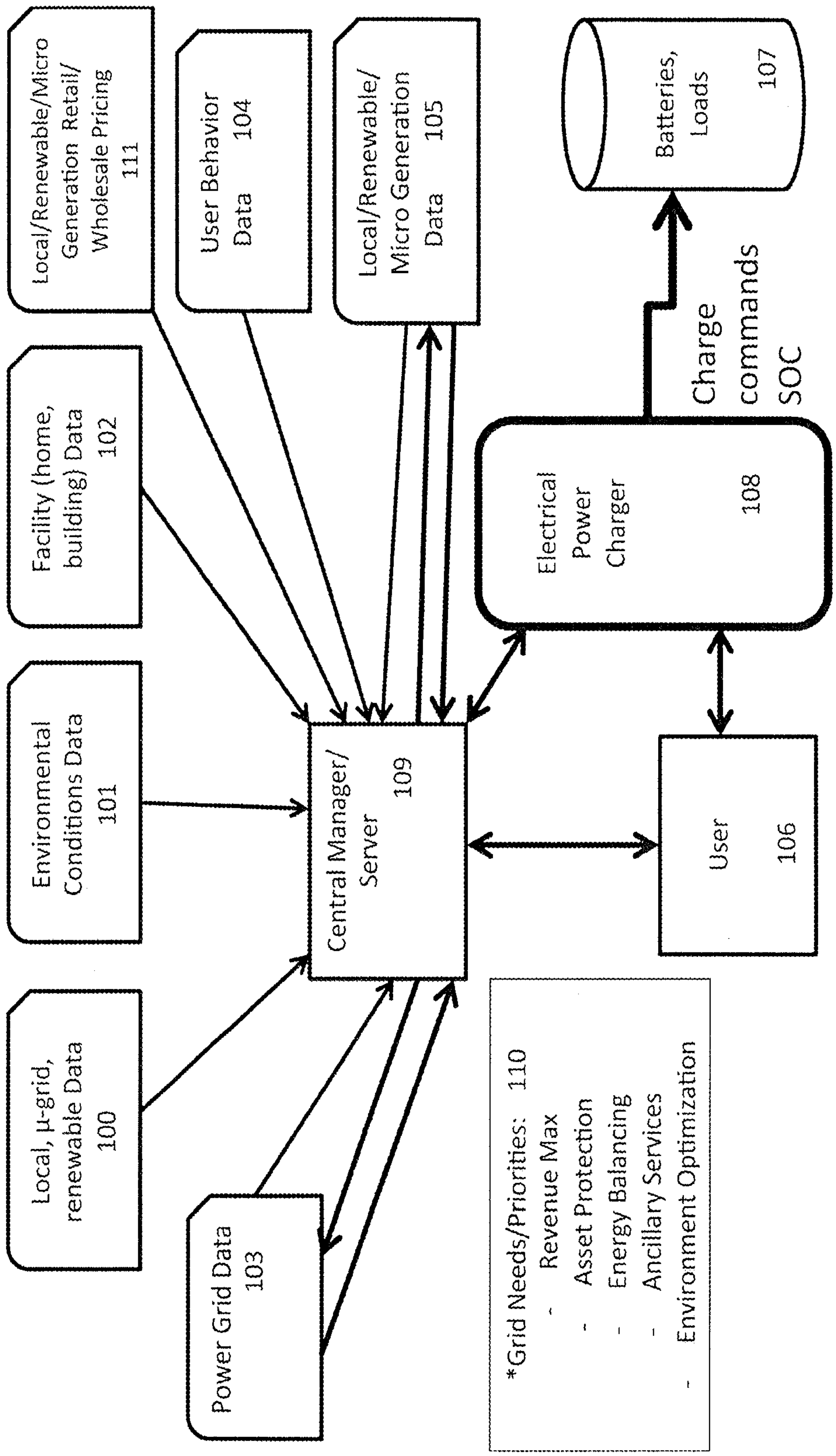

Local, µ-grid, renewable Data 100
Environmental Conditions Data 101
Facility (home, building) Data 102
Local/Renewable/Micro Generation Retail/ Wholesale Pricing 111
User Behavior Data 104
Local/Renewable/ Micro Generation Data 105
Batteries, Loads 107
Charge commands SOC
Electrical Power Charger 108
Central Manager/ Server 109
User 106
Power Grid Data 103
*Grid Needs/Priorities: 110
- Revenue Max
- Asset Protection
- Energy Balancing
- Ancillary Services
- Environment Optimization

Figure 2

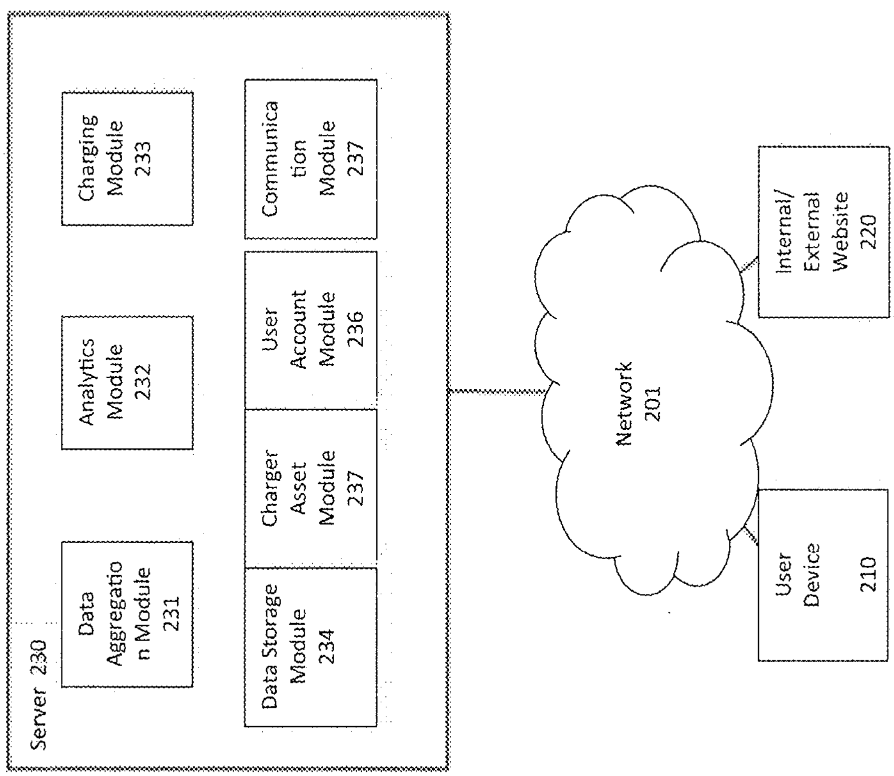

Server 230
Data Aggregation Module 231
Analytics Module 232
Charging Module 233
Data Storage Module 234
Charger Asset Module 237
User Account Module 236
Communication Module 237
Network 201
User Device 210
Internal/ External Website 220

Figure 3

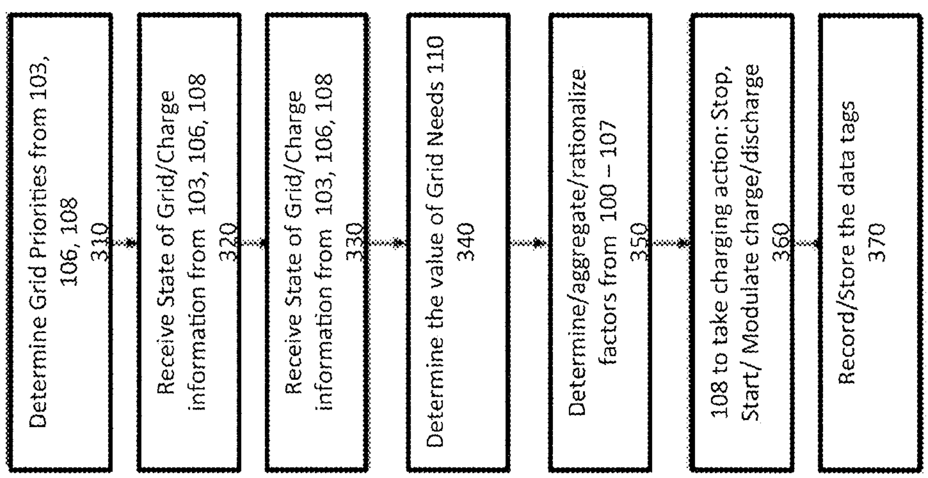
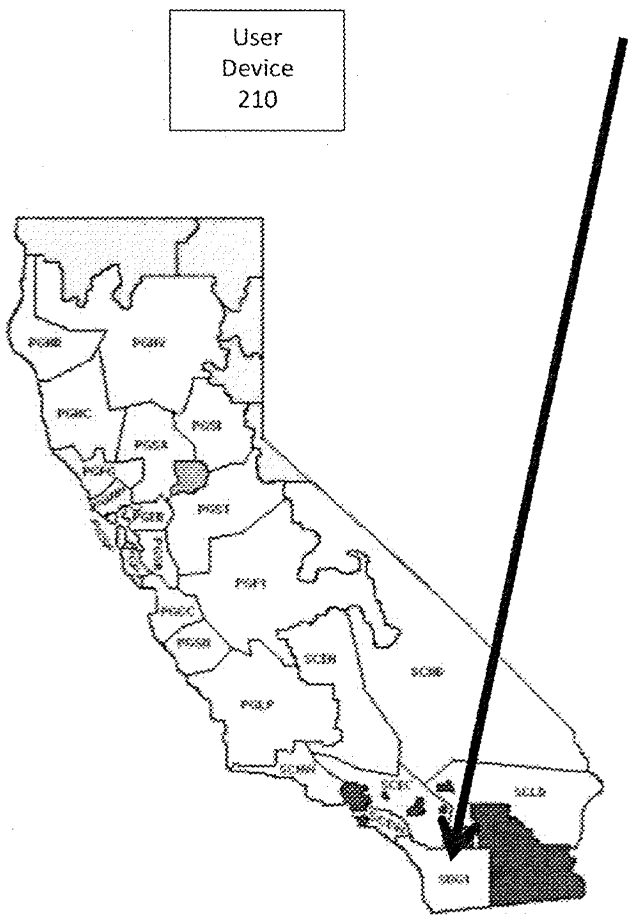

Determine Grid Priorities from 103, 106, 108
310
Receive State of Grid/Charge information from 103, 106, 108
320
Receive State of Grid/Charge information from 103, 106, 108
330
Determine the value of Grid Needs 110
340
Determine/aggregate/rationalize factors from 100 – 107
350
108 to take charging action: Stop, Start/ Modulate charge/discharge
360
Record/Store the data tags
370

Figure 4



<u>Proscribed Grid (e.g. SDG&E Sub_LAP)</u>

- **Local/Regional/State/Country**
- **Grid Needs Identified/Established**
- **All controlled charging assets within the Grid Notified**
- **Optimize economic needs based on Grid objectives**
- **Enable charging based on algorithm established**

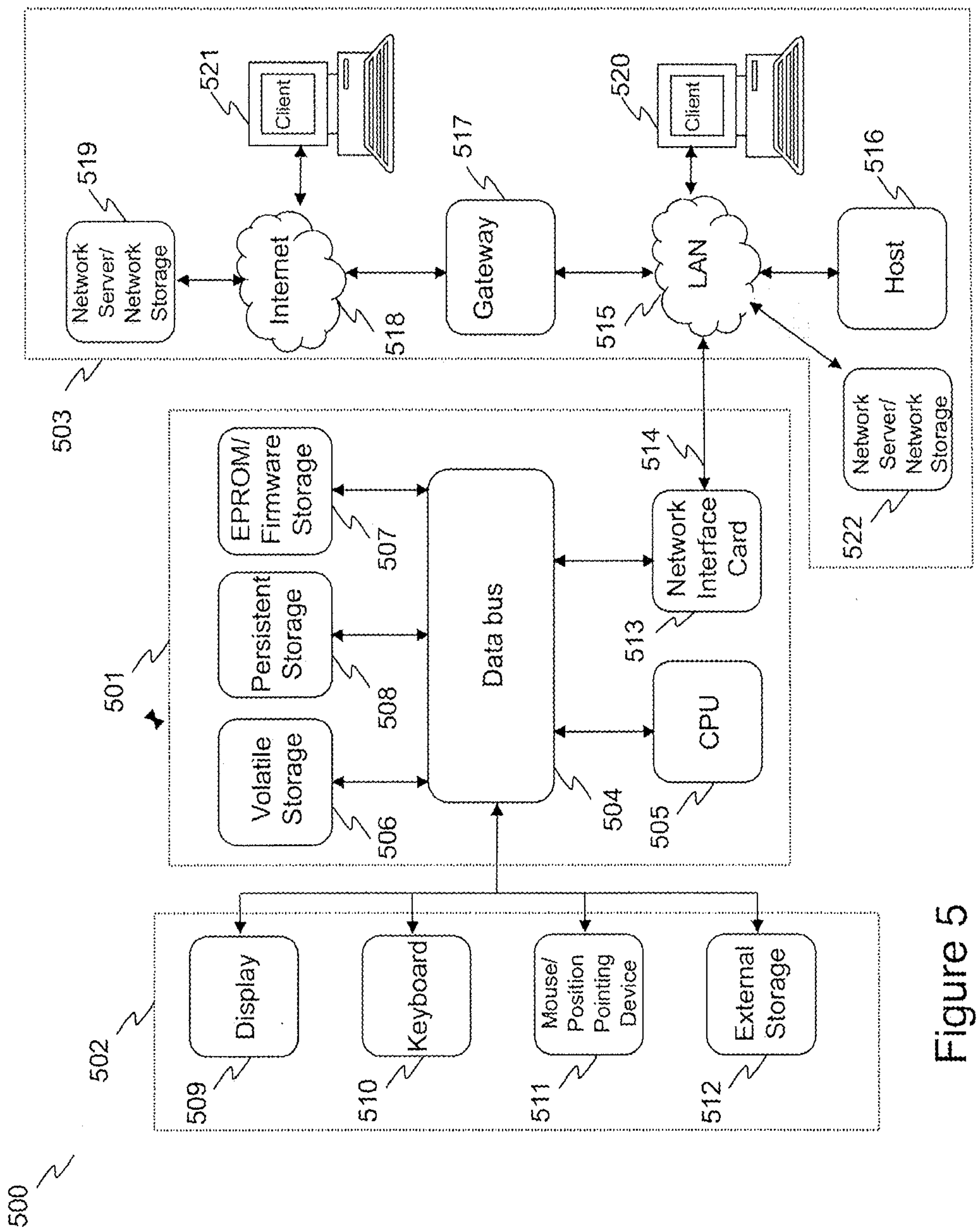

500
502
503
501
Display
Keyboard
Mouse/ Position Pointing Device
External Storage
509
510
511
512
Volatile Storage
Persistent Storage
EPROM/ Firmware Storage
506
508
507
Data bus
504
CPU
505
Network Interface Card
513
514
Network Server/ Network Storage
519
Internet
518
Client
521
Gateway
517
LAN
515
Client
520
Host
516
Network Server/ Network Storage
522

Figure 5

SYSTEMS AND METHODS FOR ELECTRICAL CHARGING LOAD MODELING SERVICES TO OPTIMIZE POWER GRID OBJECTIVES

CROSS-REFERENCE TO RELATED PATENT APPLICATION

This regular U.S. patent application relies upon, claims the benefit of priority from and is a continuation-in-part of U.S. patent application Ser. No. 14/853,955 filed on Sep. 14, 2015, which relies upon and claims the benefit of priority from U.S. provisional patent application No. 62/050,147, entitled "Grid Stabilization via a Large Distributed Collection of EV Charging Stations," filed on Sep. 14, 2014, both of which are incorporated by reference herein in their entirety. This patent application is also related to two U.S. patent applications entitled "SYSTEMS AND METHODS FOR LOCAL AUTONOMOUS RESPONSE TO GRID CONDITIONS BY ELECTRIC VEHICLE CHARGING STATIONSAS AND OTHER SIMILAR LOADS" and "COMPUTERIZED INFORMATION SYSTEM FOR SMART GRID INTEGRATED ELECTRIC VEHICLE CHARGING AND ASSOCIATED METHOD", filed on the same day and incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The disclosed embodiments relate in general to the field of electric charging technology, such as electric vehicle charging, as well as to power grid management and, more specifically, to systems and methods for electrical charging load modeling services to optimize power grid objectives.

Description of the Related Art

Today's power grid is generally managed pursuant to a top-down approach provided by Independent System Operators, Regional Transmission Operators, and Load Service Entities such as utilities, Microgrids and other large generation facilities. As distributed, local, and renewable generation and non-generating loads proliferate across territories, markets have the ability to use these resources to contribute to the supply-demand balance inherently needed for the electrical power grid. This includes but is not limited to the battery/load states connected to electric vehicle charging stations, Electric Vehicle Supply Equipment (EVSE), local battery storage, water heating, and pump storage.

A typical Electric Vehicle consumes ~10-15 KWHr of energy every day to recharge its batteries—this amount of energy is sufficient to provide ~30-50 miles of daily driving (which is consistent with a US average commute distances). A typical recharge time to transfer that amount of energy from the AC grid to the vehicle's battery is 90 minutes. However, the amount of time available for such a recharge is generally over 23 hours during a typical 24-hour day. Moreover, there are at least two blocks of this time when a typical EV spends 8+ hours in one location. These locations are usually the home of the driver and her workplace. This difference between time available and actual time required for charging creates an opportunity to reduce the instantaneous charging power and still satisfy the driver's requirements for a full vehicle battery recharge for the next day. In other words, if one were to spread the charging power uniformly over a 16-hour period (8 hours at work+8 hours at home), a typical EV can be recharged for a day of driving at just 0.6 kW average charging power.

This ability to reduce instantaneous charging power can be utilized to modulate the instantaneous electrical power drawn by a fleet of EVs by modulating charging current for each EV via EV charging stations. Such modulation capability can then be used to provide various stabilization services to the Electrical Grid (e.g., Demand Management, Frequency Regulation, Peak Shaving, Economic Demand Response, etc.). Similar to EVs, charging of other energy storage devices, such as home energy storage batteries, such as Tesla Power Wall, may also be modulated to stabilize the Electrical Grid.

Today's technology addresses these assets using binary communication that lacks an overall understanding of the objectives of each stakeholder, including the larger power grid, connected and islanded micro-grids, substations, renewable generation farms/facilities, local premises, consumer/commercial/industrial energy customers, and the generation or storage needs of each asset. Today's equipment that provides charging services has no capability to communicate nor receive inputs to identify optimal charging needs for any reason. Nor does it collect usage pattern data from a specific user or groups of users. Nor does it address existing conditions such as climate/weather, current economic needs of each stakeholder, or environmental conditions. Examples of such objectives include grid energy balancing, revenue maximization for the operator of the grid on both the wholesale and retail levels, protection or deferment of critical infrastructure, or environmental goals such as greenhouse gas emission mitigation. As a result, the time and rate of charge required to optimize all needs is not clear or well understood due to a lack of data or the ability to process the data.

Therefore, new and improved systems and methods for incorporating disparate data streams to maximize the benefits of each component of the distributed power generation and storage are needed.

SUMMARY OF THE INVENTION

The inventive methodology is directed to methods and systems that substantially obviate one or more of the above and other problems associated with conventional systems and methods for electrical vehicle charging and power grid management.

In accordance with one aspect of the embodiments described herein, there is provided a computerized system for electrical charging load modeling to optimize power grid objectives, the system incorporating a plurality of charging assets; and a cloud server comprising at least one processing unit, the cloud server incorporating: a data aggregation module configured to collect and aggregate a plurality of information items; an analytics module configured to identify at least one temporal model associated with the data collected and aggregated by the data aggregation module; a charging module configured to determine a charging pattern for each of the plurality of charging assets, the charging pattern comprising information on time intervals when each of the plurality of charging assets is to be charged, including the beginning and ending times of the charging operation and information on a level of charging during each charging time interval; a charger asset module configured to control charging of the plurality of charging assets in accordance with the determined charging patterns by issuing a control command to each of the plurality of charging assets; and a communication module for communicating the control command issued by the charger asset module to the respective charging asset via a data network.

In one or more embodiments, the plurality of information items comprises a power grid data.

In one or more embodiments, the plurality of information items comprises a data collected from local grids, the local grids comprising residential renewables, local or regional microgrids.

In one or more embodiments, the plurality of information items comprises data originating from an external environment.

In one or more embodiments, the data originating from an external environment comprises weather-related information, solar activity information, cloud-cover information or earthquake information.

In one or more embodiments, the plurality of information items comprises data representing energy needs of individual or groups of electric energy users.

In one or more embodiments, the plurality of information items comprises data on specific users of electrical power and their individual behavior.

In one or more embodiments, the plurality of information items comprises data on energy storage, including any available EV batteries, power storage batteries, as well as data on any energy coming from Load-Serving-Entities.

In one or more embodiments, the plurality of information items comprises data on a specific one of the plurality of charging assets.

In one or more embodiments, the plurality of information items comprises data on a power grid priorities.

In one or more embodiments, the data on a power grid priorities comprises information on maximization of revenue, protecting assets, balancing energy, reducing emissions, or delivering ancillary services.

In accordance with another aspect of the embodiments described herein, there is provided a computer-implemented method for electrical charging load modeling to optimize power grid objectives, the method being performed in connection with a plurality of charging assets and a cloud server incorporating at least one processing unit, the method involving: collecting and aggregating a plurality of information items; identifying at least one temporal model associated with the collected and aggregated plurality of information items; determining a charging pattern for each of the plurality of charging assets, the charging pattern comprising information on time intervals when each of the plurality of charging assets is to be charged, including the beginning and ending times of the charging operation and information on a level of charging during each charging time interval; controlling charging of the plurality of charging assets in accordance with the determined charging patterns by issuing a control command to each of the plurality of charging assets; and communicating the control command issued by the charger asset module to the respective charging asset via a data network.

In one or more embodiments, the plurality of information items comprises a power grid data.

In one or more embodiments, the plurality of information items comprises a data collected from local grids, the local grids comprising residential renewables, local or regional microgrids.

In one or more embodiments, the plurality of information items comprises data originating from an external environment.

In one or more embodiments, the data originating from an external environment comprises weather-related information, solar activity information, cloud-cover information or earthquake information.

In one or more embodiments, the plurality of information items comprises data representing energy needs of individual or groups of electric energy users.

In one or more embodiments, the plurality of information items comprises data on specific users of electrical power and their individual behavior.

In one or more embodiments, the plurality of information items comprises data on energy storage, including any available EV batteries, power storage batteries, as well as data on any energy coming from Load-Serving-Entities.

In one or more embodiments, the plurality of information items comprises data on a specific one of the plurality of charging assets.

In one or more embodiments, the plurality of information items comprises data on a power grid priorities.

In one or more embodiments, the data on a power grid priorities comprises information on maximization of revenue, protecting assets, balancing energy, reducing emissions, or delivering ancillary services.

Additional aspects related to the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. Aspects of the invention may be realized and attained by means of the elements and combinations of various elements and aspects particularly pointed out in the following detailed description and the appended claims.

It is to be understood that both the foregoing and the following descriptions are exemplary and explanatory only and are not intended to limit the claimed invention or application thereof in any manner whatsoever.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification exemplify the embodiments of the present invention and, together with the description, serve to explain and illustrate principles of the inventive technique. Specifically:

FIG. **1** illustrates a logical diagram of an exemplary embodiment of a computerized system for electrical charging load modeling services to optimize power grid objectives.

FIG. **2** illustrates a logical diagram of another exemplary embodiment of a computerized system for electrical charging load modeling services to optimize power grid objectives.

FIG. **3** illustrates an operating sequence of an exemplary embodiment of a computerized system for electrical charging load modeling services to optimize power grid objectives.

FIG. **4** illustrates a graphical use interface generated on a user's mobile device by an exemplary embodiment of a computerized system for electrical charging load modeling services to optimize power grid objectives.

FIG. **5** is a block diagram that illustrates an embodiment of a computer/server platform upon which an embodiment of the inventive system for electrical charging load modeling services to optimize power grid objectives may be deployed.

DETAILED DESCRIPTION

In the following detailed description, reference will be made to the accompanying drawing(s), in which identical functional elements are designated with like numerals. The aforementioned accompanying drawings show by way of illustration, and not by way of limitation, specific embodi-

ments and implementations consistent with principles of the present invention. These implementations are described in sufficient detail to enable those skilled in the art to practice the invention and it is to be understood that other implementations may be utilized and that structural changes and/or substitutions of various elements may be made without departing from the scope and spirit of present invention. The following detailed description is, therefore, not to be construed in a limited sense.

In accordance with one aspect of the embodiments described herein, there is provided a novel system, which is configured to receive and automatically analyze various types of information, including, without limitation, information from energy generators, information from non-generation resources, information on the facility status, information on user behavior, information on user's short-term energy needs (e.g. over-ride any algorithm due to immediate charging need), information on renewable generation, including, without limitation, solar, wind, biomass and/or hydro, and information on environmental conditions including, without limitation, barometric pressure, temperature, ambient light intensity, humidity, air speed, and air quality. In one or more embodiments, a sole novel charging station or selected, aggregated groupings of the aforesaid novel charging stations are configured to start, modulate or stop charging, or start, modulate (down) or stop discharging over specific time intervals based on the electrical grid needs as automatically determined based on the totality of the received diverse information. To this end, a system and an associated method are provided to perform complete electrical charging load modeling to optimize power grid objectives.

FIG. 1 illustrates a logical diagram of an exemplary embodiment of a computerized system for complete electrical charging load modeling to optimize electric power grid objectives. In one or more embodiments, the system shown in FIG. 1 incorporates a cloud-based server 109 which is configured to collect and analyze the aforesaid various types of information and to generate output, including commands for controlling electrical power charger 108 in a manner that advances the power grid objectives. To this end, the cloud-based server 109 executes one or more software modules that implement algorithms developed based on the systems and methods described herein.

As shown in FIG. 1, in one or more embodiments, the cloud-based server 109 receives power grid data 103, which could be various data coming from traditional power grids. In various embodiments, the power grid data 103 could include one or more readings from one or more sensors disposed within the aforesaid power grid. The aforesaid power grid data 103 as well as any other data described herein may be received by the cloud-based server 109 via a wired or wireless computer data network connection, which are well known to persons of ordinary skill in the art. In one or more embodiments, the aforesaid power grid data 103 is collected from transmission or distribution assets of the grid.

In addition to the power grid data 103, the cloud-based server 109 receives data 100 collected from various local grids, including residential renewables, local or regional microgrids. In addition, in one or more embodiments, the cloud-based server 109 receives data 101, which includes various data originating from the external environment, including, without limitation, weather-related information, such as wind information, including direction, speed and gusts, solar activity information, cloud-cover information, earthquake information, as well as news-feeds, and any other information relevant to the operation of the electrical grid.

Yet additionally, in one or more embodiments, the cloud-based server 109 receives information on load-receiving entities such as residences, commercial buildings, and industrial facilities. Such data may include the number and types of such entities, their respective energy demands and patterns of energy usage during various time periods, including daily and seasonal energy usage patterns.

Furthermore, in one or more embodiments, the cloud-based server 109 additionally receives information on electric energy unit pricing from wholesale electric energy markets, retail electricity sellers, microgrid operators, and renewable electrical energy sources. In addition, in one or more embodiments, the cloud-based server 109 receives data 104 representing the energy needs of individual or groups of electric energy users. In various embodiments, the received data includes user's EV charging behavior, electric heating usage, water heating needs, HVAC usage, or water pumps usage.

In addition, in one or more embodiments, the cloud-based server 109 receives data 106 representing data on specific users of electrical power and their individual behavior. This data 106 may correlate with the aforesaid data 104 and is collected using the same process.

Moreover, in one or more embodiments, the cloud-based server 109 receives data 107, which represents information on any energy storage, including any available EV batteries, power storage batteries, such as Tesla Power Wall, as well as data on any energy coming from Load-Serving-Entities, well known to persons of ordinary skill in the art. Additionally, in one or more embodiments, the cloud-based server 109 receives data 108, which represents information on a specific charging device, such as an EV charging station, being controlled by the systems and methods described herein. Finally, in one or more embodiments, the cloud-based server 109 receives data 110, which describes the locus of power grid priorities, including the information on the needs to maximize revenue, protect assets, balance energy, reduce GHGs, and deliver ancillary services. In various embodiments, relative rank or weight may be assigned to each such priority and included within the data 110. As would be appreciated by persons of ordinary skill in the art, the grid priority information may be communicated using any other means as well.

Once received, some or all of the above data items are analyzed by the cloud-based server 109 in accordance with one or more algorithms embedded therein.

FIG. 2 illustrates a logical diagram of another exemplary embodiment of a computerized system for electrical charging load modeling services to optimize power grid objectives. Some of the logical modules shown in FIG. 2 may be deployed on the cloud-based server 230, which may generally correspond to the cloud-based server 109 in FIG. 1. Specifically, deployed on the cloud-based server 230 may be a data aggregation module 231, which collects and aggregates the specific data items illustrated in FIG. 1, as well as other relevant data. The data aggregation module 231 may also furnish the collected and aggregated data to other modules deployed on the cloud-based server 230 or other local or remote software applications, such as user's mobile application.

In one or more embodiments, also deployed on the cloud-based server 230 is an analytics module 232, which identifies various temporal models and/or behaviors associated with the data collected using the systems and methods

described herein. In addition, the cloud-based server **230** also executes a charging module **233** operable to determine specific charging patterns for one or more charging assets, such as EV charging stations, based on the data items received and aggregated by the aggregation module **231** and analyzed by the analytics module **232**, as described above. The aforesaid charging patterns calculated by the charging module **233** include, without limitation, information on the time intervals when each specific asset will be charged, including the beginning and ending times of the charging operation as well as information on the level of charging during each charging time interval.

In one or more embodiments, additionally deployed on the cloud-based server **230** is a data storage module **234**, which stores and manages the data collected as described in FIG. **1**. In various embodiments, the data storage module **234** may be implemented based on any now known or later developed type of database management system, such as a relational database management system, including MySQL, Oracle, SQL Server, DB2, SQL Anywhere, PostgreSQL, SQLite, Firebird, redis, MongoDB, Hadoop and/or MaxDB. A cloud-based distributed database, such as Amazon Relational Database Service (Amazon RDS), may also be used in implementing the storage module **234**.

In one or more embodiments, additionally deployed on the cloud-based server **230** is a charger asset module **235**, which is configured to control charging of select electrical assets in accordance with the aforesaid charging patterns calculated by the charging module **233**.

In one or more embodiments, further deployed on the cloud-based server **230** is a user account module **236**, which stores and manages various information on users of the described system, their setting, preferences, patterns and other user-related data. In various embodiments, the user account module **236** furnishes the user information to other modules of the system. In one or more embodiments, yet further deployed on the cloud-based server **230** is a communication module **237**, which communicatively connects various networked assets of the described system, such as the cloud-based server **230**, the chargers, and loads to ensure that the modeled actions described herein can be taken. In various embodiments, for example, the communication module **237** communicates the commands issued by the charger asset module **235** in accordance with the charging patterns calculated by the charging module **233** to the respective EV charger stations. In various embodiments, the communication between the aforesaid networked assets takes place via a network **201**, which may be implemented using any now known or later developed wireless or wired network interconnect.

In various embodiments, the exemplary embodiment of the system shown in FIG. **2** may further include one or more user device(s) **210** connected to network **201**. The user of the described system may use the user device(s) **210** to access various information and issue various commands to one or more modules deployed on the cloud-based server **230**.

Finally, the exemplary embodiment of the system shown in FIG. **2** may further incorporate various web resources **220**, such as websites, internal, or external, which may be configured to provide to the users various relevant data and information for user consumption and aiding users in decision-making. Such relevant data and information may include any data items described hereinabove as well as results of analysis of any such data, founds trends, patterns, predictions, etc. The data and analytics may be presented to the user in textual or graphical form. In various embodiments, the user may access the data and analytics using the user device(s) **210**.

FIG. **3** illustrates an operating sequence of an exemplary embodiment of a software algorithm for electrical charging load modeling services to optimize power grid objectives as described herein. First, at step **310**, the inventive computerized system for electrical charging load modeling services to optimize power grid objectives uses the power grid data **103**, the user data **106** and the data provided by the electrical power charger **108** to automatically determine the grid priorities, see FIG. **1**. Subsequently, at steps **320** and **330**, the computerized system for electrical charging load modeling services to optimize power grid objectives determines the state of charge based on the aforesaid user, charging, power, renewable, and microgrid-related data.

After that, at step **340**, the system determines the optimal parameter values to ensure the maximum for grid efficiency from a cost, environmental, and balancing/services standpoints. At step **350**, the computerized system for electrical charging load modeling services to optimize power grid objectives determines, aggregates and rationalizes various factors using data items **100-107** shown in FIG. **1**. At step **360**, the computerized system for electrical charging load modeling services to optimize power grid objectives directs the electric power charger **108** to take an appropriate charging action, such as to start, stop and/or modulate the charging of an asset. This charging action is determined, as described above, based on the totality of the received diverse data items. Finally, the data tags describing the charging action and any associated data are stored (recorded) on appropriate storage media at step **370**.

FIG. **4** illustrates a graphical use interface generated on a user's mobile device **210** by an exemplary embodiment of a computerized system for electrical charging load modeling services to optimize power grid objectives. In one or more embodiments, the user interface displayed by the mobile device **210** is specific to the region/geography, which is being acted upon to maximize revenue from a specific electricity market.

Exemplary Computer Platform

FIG. **5** is a block diagram that illustrates an embodiment of a computer/server system **500** upon which an embodiment of the inventive methodology may be implemented. The system **500** includes a computer/server platform **501**, peripheral devices **502** and network resources **503**. In various embodiments the aforesaid computer/server system **500** may function as the cloud-based servers **109** and/or **230** described above.

The computer platform **501** may include a data bus **505** or other communication mechanism for communicating information across and among various parts of the computer platform **501**, and a processor **505** coupled with bus **501** for processing information and performing other computational and control tasks. Computer platform **501** also includes a volatile storage **506**, such as a random access memory (RAM) or other dynamic storage device, coupled to bus **505** for storing various information as well as instructions to be executed by processor **505**. The volatile storage **506** also may be used for storing temporary variables or other intermediate information during execution of instructions by processor **505**. Computer platform **501** may further include a read only memory (ROM or EPROM) **507** or other static storage device coupled to bus **504** for storing static information and instructions for processor **505**, such as basic input-output system (BIOS), as well as various system configuration parameters. A persistent storage device **508**,

such as a magnetic disk, optical disk, or solid-state flash memory device is provided and coupled to bus **501** for storing information and instructions.

Computer platform **501** may be coupled via bus **505** to a display **509**, such as a cathode ray tube (CRT), plasma display, or a liquid crystal display (LCD), for displaying information to a system administrator or user of the computer platform **501**. An input device **510**, including alphanumeric and other keys, is coupled to bus **501** for communicating information and command selections to processor **505**. Another type of user input device is cursor control device **511**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **505** and for controlling cursor movement on display **509**. This input device typically has two degrees of freedom in two axes, a first axis (e.g., x) and a second axis (e.g., y), that allows the device to specify positions in a plane.

An external storage device **512** may be coupled to the computer platform **501** via bus **505** to provide an extra or removable storage capacity for the computer platform **501**. In an embodiment of the computer system **500**, the external removable storage device **512** may be used to facilitate exchange of data with other computer systems.

The invention is related to the use of computer system **500** for implementing the techniques described herein. In an embodiment, the inventive system may reside on a machine such as computer platform **501**. According to one embodiment of the invention, the techniques described herein are performed by computer system **500** in response to processor **505** executing one or more sequences of one or more instructions contained in the volatile memory **506**. Such instructions may be read into volatile memory **506** from another computer-readable medium, such as persistent storage device **508**. Execution of the sequences of instructions contained in the volatile memory **506** causes processor **505** to perform the process steps described herein. In alternative embodiments, hard-wired circuitry may be used in place of or in combination with software instructions to implement the invention. Thus, embodiments of the invention are not limited to any specific combination of hardware circuitry and software.

The term "computer-readable medium" as used herein refers to any medium that participates in providing instructions to processor **505** for execution. The computer-readable medium is just one example of a machine-readable medium, which may carry instructions for implementing any of the methods and/or techniques described herein. Such a medium may take many forms, including but not limited to, non-volatile media and volatile media. Non-volatile media includes, for example, optical or magnetic disks, such as storage device **508**. Volatile media includes dynamic memory, such as volatile storage **506**.

Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, or any other magnetic medium, a CD-ROM, any other optical medium, punchcards, papertape, any other physical medium with patterns of holes, a RAM, a PROM, an EPROM, a FLASH-EPROM, a flash drive, a memory card, any other memory chip or cartridge, or any other medium from which a computer can read.

Various forms of computer readable media may be involved in carrying one or more sequences of one or more instructions to processor **505** for execution. For example, the instructions may initially be carried on a magnetic disk from a remote computer. Alternatively, a remote computer can load the instructions into its dynamic memory and send the instructions over a telephone line using a modem. A modem local to computer system can receive the data on the telephone line and use an infra-red transmitter to convert the data to an infra-red signal. An infra-red detector can receive the data carried in the infra-red signal and appropriate circuitry can place the data on the data bus **505**. The bus **505** carries the data to the volatile storage **506**, from which processor **505** retrieves and executes the instructions. The instructions received by the volatile memory **506** may optionally be stored on persistent storage device **508** either before or after execution by processor **505**. The instructions may also be downloaded into the computer platform **501** via Internet using a variety of network data communication protocols well known in the art.

The computer platform **501** also includes a communication interface, such as network interface card **513** coupled to the data bus **505**. Communication interface **513** provides a two-way data communication coupling to a network link **515** that is coupled to a local network **515**. For example, communication interface **513** may be an integrated services digital network (ISDN) card or a modem to provide a data communication connection to a corresponding type of telephone line. As another example, communication interface **513** may be a local area network interface card (LAN NIC) to provide a data communication connection to a compatible LAN. Wireless links, such as well-known 802.11a, 802.11b, 802.11g and Bluetooth may also used for network implementation. In any such implementation, communication interface **513** sends and receives electrical, electromagnetic or optical signals that carry digital data streams representing various types of information.

Network link **515** typically provides data communication through one or more networks to other network resources. For example, network link **515** may provide a connection through local network **515** to a host computer **516**, or a network storage/server **517**. Additionally or alternatively, the network link **513** may connect through gateway/firewall **517** to the wide-area or global network **518**, such as an Internet. Thus, the computer platform **501** can access network resources located anywhere on the Internet **518**, such as a remote network storage/server **519**. On the other hand, the computer platform **501** may also be accessed by clients located anywhere on the local area network **515** and/or the Internet **518**. The network clients **520** and **521** may themselves be implemented based on the computer platform similar to the platform **501**.

Local network **515** and the Internet **518** both use electrical, electromagnetic or optical signals that carry digital data streams. The signals through the various networks and the signals on network link **515** and through communication interface **513**, which carry the digital data to and from computer platform **501**, are exemplary forms of carrier waves transporting the information.

Computer platform **501** can send messages and receive data, including program code, through the variety of network(s) including Internet **518** and LAN **515**, network link **515** and communication interface **513**. In the Internet example, when the system **501** acts as a network server, it might transmit a requested code or data for an application program running on client(s) **520** and/or **521** through Internet **518**, gateway/firewall **517**, local area network **515** and communication interface **513**. Similarly, it may receive code from other network resources.

The received code may be executed by processor **505** as it is received, and/or stored in persistent or volatile storage devices **508** and **506**, respectively, or other non-volatile storage for later execution.

Finally, it should be understood that processes and techniques described herein are not inherently related to any particular apparatus and may be implemented by any suitable combination of components. Further, various types of general purpose devices may be used in accordance with the teachings described herein. It may also prove advantageous to construct specialized apparatus to perform the method steps described herein. The present invention has been described in relation to particular examples, which are intended in all respects to be illustrative rather than restrictive.

Moreover, other implementations of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. Various aspects and/or components of the described embodiments may be used singly or in any combination in systems and methods for electrical charging load modeling services to optimize power grid objectives. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A computerized system for electrical charging load modeling to optimize power grid objectives, the system comprising:

a. a plurality of charging assets; and

b. a cloud server comprising at least one processing unit, the cloud server comprising:

i. a data aggregation module configured to collect and aggregate a plurality of information items;

ii. an analytics module configured to identify at least one temporal model associated with the data collected and aggregated by the data aggregation module;

iii. a charging module configured to determine a charging pattern for each of the plurality of charging assets, the charging pattern comprising information on time intervals when each of the plurality of charging assets is to be charged, including the beginning and ending times of the charging operation and information on a level of charging during each charging time interval;

iv. a charger asset module configured to control charging of the plurality of charging assets in accordance with the determined charging patterns by issuing a control command to each of the plurality of charging assets; and

v. a communication module for communicating the control command issued by the charger asset module to the respective charging asset via a data network.

2. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises a power grid data.

3. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises a data collected from local grids, the local grids comprising residential renewables, local or regional microgrids.

4. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises data originating from an external environment.

5. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **4**, wherein the data originating from an external environment comprises weather-related information, solar activity information, cloud-cover information or earthquake information.

6. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises data representing energy needs of individual or groups of electric energy users.

7. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises data on specific users of electrical power and their individual behavior.

8. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises data on energy storage, including any available EV batteries, power storage batteries, as well as data on any energy coming from Load-Serving-Entities.

9. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises data on a specific one of the plurality of charging assets.

10. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the plurality of information items comprises data on a power grid priorities.

11. The computerized system for electrical charging load modeling to optimize power grid objectives of claim **1**, wherein the data on a power grid priorities comprises information on maximization of revenue, protecting assets, balancing energy, reducing emissions, or delivering ancillary services.

12. A computer-implemented method for electrical charging load modeling to optimize power grid objectives, the method being performed in connection with a plurality of charging assets and a cloud server comprising at least one processing unit, the method comprising:

i. collecting and aggregating a plurality of information items;

ii. identifying at least one temporal model associated with the collected and aggregated plurality of information items;

iii. determining a charging pattern for each of the plurality of charging assets, the charging pattern comprising information on time intervals when each of the plurality of charging assets is to be charged, including the beginning and ending times of the charging operation and information on a level of charging during each charging time interval;

iv. controlling charging of the plurality of charging assets in accordance with the determined charging patterns by issuing a control command to each of the plurality of charging assets; and

v. communicating the control command issued by the charger asset module to the respective charging asset via a data network.

13. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim **12**, wherein the plurality of information items comprises a power grid data.

14. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim **12**, wherein the plurality of information items comprises a data collected from local grids, the local grids comprising residential renewables, local or regional microgrids.

15. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim 12, wherein the plurality of information items comprises data originating from an external environment.

16. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim 15, wherein the data originating from an external environment comprises weather-related information, solar activity information, cloud-cover information or earthquake information.

17. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim 12, wherein the plurality of information items comprises data representing energy needs of individual or groups of electric energy users.

18. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim 12, wherein the plurality of information items comprises data on specific users of electrical power and their individual behavior.

19. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim 12, wherein the plurality of information items comprises data on energy storage, including any available EV batteries, power storage batteries, as well as data on any energy coming from Load-Serving-Entities.

20. The computer-implemented method for electrical charging load modeling to optimize power grid objectives of claim 12, wherein the plurality of information items comprises data on a specific one of the plurality of charging assets.

* * * * *